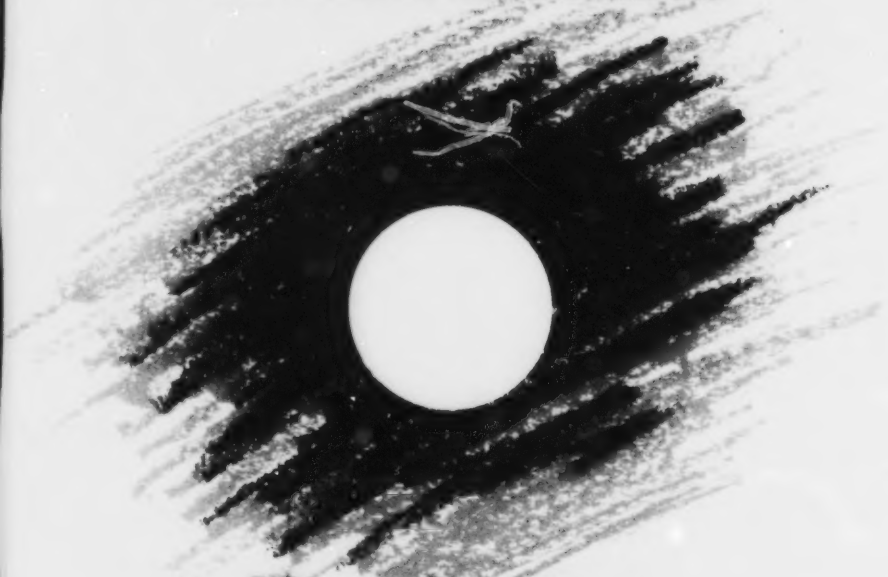
Emissions Permit Trading:

A Policy Tool to Reduce the Atmospheric Concentration of Greenhouse Gases



Merete Heggelund

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MERETE HEGGELUND

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PREFACE

The study author wishes to express her gratitude to the fifteen member advisory committee that reviewed this study prior to publication. Their comments and insights substantially enhanced the quality of this report.

Many thanks are also extended to a number of Institute staff who contributed to the study. Shawna Braun revised numerous drafts, Megan Murphy produced the graphics and Nancy Sanford proof-read and edited the final report. The staff of the I.N. McKinnon Memorial Library helped gather source material. Special thanks are due to Len Coad for his support, guidance and encouragement throughout the project. Dr. Gerry Angevine and Anthony Reinsch also reviewed the study and provided valuable comments. The author is responsible for any remaining errors or omissions.

EXECUTIVE SUMMARY

Introduction

Human activities are changing the earth's atmosphere at an unprecedented rate. The greenhouse effect can be attributed to the emission of certain trace gases into the atmosphere, but there is significant scientific controversy over the magnitude, timing and regional impacts of global warming.

There are a host of trace gases that contribute to the greenhouse effect. CFCs, N_2O and methane have a much greater warming potential than CO_2 on a molecule by molecule basis, but the large volumes involved make CO_2 the single most important of the greenhouse gases. CO_2 is responsible for approximately 50 percent of the potential warming of the atmosphere. Large-scale reductions in CO_2 levels will require costly, fundamental changes both in production processes and consumption patterns.

There are many unknown factors related to the life-cycle of CO_2 emissions. The carbon cycle includes delayed effects and carbon sinks that may offer opportunities to offset rising emission levels. It is important to distinguish between net and gross carbon emissions from a source. However, the present uncertainty with respect to the potentially offsetting effect of carbon sinks makes measurement of net carbon emissions a difficult proposition.

In Canada, the largest sources of CO_2 emissions are fossil fuel combustion in the transportation, industrial and electric utility sectors, and in some industrial processes.

- **Recognizing the wide-spread nature of CO_2 emissions and the divergent characteristics of emission sources, a practical policy response must consist of several initiatives as opposed to a single "best" policy option.**

Climate change is a global problem. The issues related to greenhouse gas emissions must be analysed and addressed in an international context to ensure effective and efficient responses while accommodating the needs of developing regions. It is also important to avoid creating competitive distortions in international trade when implementing a domestic emissions policy.

Several industrial countries, including Canada, have adopted an interim target of freezing CO_2 emissions at the 1990 level by the year 2000. Some countries have gone further and committed to 20 to 35 percent reduction targets in this time frame.

While recognizing the global nature of the problem, this study does not attempt to address these broader issues. Rather, the report assumes that Canada has negotiated an internationally compatible domestic emissions target and, hence, proceeds to examine the issues related to implementing a domestic permit trading policy.

The Theory of Permit Trading

The command and control approach to regulation has been the prevalent policy tool used by government authorities in an effort to limit polluting emissions and to maintain environmental quality standards imposed by the state. This approach distributes control responsibility among the sources of discharge by assigning separate emission standards for each point of discharge. Standards are usually uniform, at least for broad classes of sources. This uniformity can result in very different marginal costs of emission control between sources. In forcing each source to control up to a certain level of emissions, some high-cost solutions to emission control are implemented while other low-cost sources may remain unexploited.

The potential for large cost penalties associated with the regulatory approach has led researchers to examine alternative means of allocating control responsibility through the establishment of a system of emission permits or licenses. Such a system involves the assignment of private ownership to the limited permits to discharge pollutants into the air. It then relies on the incentives of the market to achieve aggregate emission target levels in the most cost-effective manner. Market based incentive systems give the emission sources the flexibility to reallocate control initiatives, so that low-cost sources control relatively more, and high-cost sources relatively smaller quantities of emissions.

The operation of an emission permit system requires that a control authority determines the desired level of aggregate emissions in the atmosphere and, accordingly, issues an initial offering of licenses to emitting sources such that emission levels remain equal to or below that level. In addition, the control authority is required to organize a formal market for the trading of emissions, and enforce the emission limits by imposing noncompliance constraints. Each

emission license defines the allowable total emission discharge for the owner over a specified period. Given the initial offering of licenses, profit maximizing firms in the economy would engage in trading of the licenses so as to minimize the costs imposed upon them by emission constraints.

In the market equilibrium when all sources are operating according to conditions for cost minimization, the marginal cost of pollution control is equalized across all sources. Intuitively, this is a reasonable result, in that an incentive will certainly exist for sources with relatively low marginal costs of control to increase their level of control and to sell excess emission permits, the value of which should exceed additional control costs incurred. Similarly, sources with relatively high marginal costs of control will find it less costly to purchase emission permits than to install additional control equipment.

The theoretical assessment of a permit trading system made it possible to outline a series of specific conditions necessary for establishing a successful trading program.

- To avoid strategic behaviour and manipulation of the allocation of permits or the permit price, there must be a sufficiently large number of emitters in a trading program to establish a competitive market.
- The more diverse the costs of compliance, the larger are the potential benefits from trade.
- The fewer the restrictions placed on transferability of permits, the closer the market will come to achieving the lowest cost of compliance.
- It is much easier to establish a trading program for a uniformly mixed pollutant than for emissions that cause damage to specific areas or during specific time periods.
- Auctioning permits may lead to cost increases for the polluters that negate the cost savings of a permit system relative to a uniform regulatory approach.
- Market manipulative behaviour in a non-competitive permit market can be eliminated by implementing an incentive compatible auction system. If the costs of purchasing permits are deemed too excessive, an auction-refund system can be designed to allow for initial distribution of permits in accordance with their individual costs of compliance.

- A free allocation of permits that provides an incentive to trade, represents a wealth transfer policy. As such, any allocation formula must be subject to economic impact analysis and accompanied by a policy statement.

As these conclusions were based on the theory of permit trading, they do not include the more practical problems such as enforcement and monitoring, and establishing appropriate benchmarks as a basis for permit allocation. A brief comparison of policy options served to highlight the different characteristics of some of the policy tools and, thereby, provide further insight into the conditions under which a tradeable permit system would be likely to succeed.

- While emission taxes and permits will in theory achieve the same goal of cost minimization, the uncertainty related to choosing the right tax rate for achieving a certain quantity of emission reductions gives permits an advantage as a practical policy tool when the environmental goal is expressed as a quantity target.

- If current concentrations of emissions are close to a threshold for environmental damage, it is particularly important to achieve the desired quantity of emissions.

- Permits may also have an advantage over taxes in political acceptability, in flexibility to accommodate economic growth and inflation, and in providing an incentive for technological advances.

- On the other hand, an emissions tax may be preferred if the control costs are rapidly escalating or are unknown, since this would directly control the costs of compliance.

- Given that a permit system could not be universally applied, a tax policy may have greater overall effectiveness. And although adjustments to a tax rate would need to be more frequent and would be politically unpopular, the withdrawal of permits before the set expiry date may prove difficult, leaving authorities less control to adjust the permit policy once implemented.

- Alternative tax policies such as energy excise taxes, manufacturing product taxes or carbon taxes on fuels, are not likely to achieve the socially optimal, least-cost solution, but they have the advantage of ease of implementation and monitoring compared to an emission policy.

The Experience with Permit Trading

Several emission trading programs in the United States are reviewed to provide some insight into the practical implementation of this policy tool.

Under these emissions trading programs, difficulty has been experienced in defining baselines and reductions from baselines, which in turn define emission credits. The difficulty in calculating these values has created uncertainty for polluters as to what surplus reductions will be recognized by state authorities. The costs which firms must incur to resolve such uncertainties serve to deter participation in the emissions trading market. Furthermore, the uncertainty as to whether property rights for emission reduction credits, once established, will remain with the source without discounts or confiscation by a state authority has also served to restrict trading activity. On the other hand, the relative success of the lead trading market has been attributed, in part, to the creation of a market with clearly defined property rights for lead reductions.

A banking program which serves to identify potential buyers and sellers of emission permits can alleviate the search costs involved in identifying potential external trades. Such costs inevitably act as a disincentive for firms to engage in trading of emissions, while they encourage firms to use emission credits for internal transactions. They also tend to limit trades to larger companies. High transaction costs associated with the approval process for trades similarly discourage market participation and, consequently, cost saving potentials are not realized.

The degree to which trading of emissions is restricted by the regulatory constraints imposed on individual sources is an important determining factor of the success of any market approach to emission control. Ideally, under a market approach, those sources which can provide control at the least cost will be responsible for achieving emissions reductions targets. However, under the United States regulatory structure, new sources are required to maintain minimum levels of control, regardless of the costs involved. The imposition of a standard which makes distinctions among sources in this way creates rigidities in the control options, and the potential cost savings of the more flexible emissions trading approach are reduced. Finally, these case

studies illustrate that the market must be large and diverse enough to accommodate competitive trading, in order for cost efficiency to be achieved.

The experience with permit systems reconfirmed the theoretical conclusions that success of the trading policy is contingent on an unrestricted, competitive permit market. Furthermore, the issues that are easily assumed away in theory, such as establishment of benchmarks, issue of property rights and intertemporal allocation, are potential stumbling blocks in practice. This reinforces the general conclusion that a permit trading policy needs to be complete and well formulated at the outset to counteract the inevitable uncertainty of a real market.

The Feasibility of CO_2 Permit Trading in Canada

A CO_2 permit market in Canada should include large industrial sources and the electricity generation sector, potentially covering 40 percent of total national emissions. The possibility of including vehicle fleets from the transportation sector should also be investigated. In addition, continued research may open the possibility for a future expansion of the program to include other greenhouse gases such as methane and nitrous oxide, to allow for credits from reforestation or creation of other carbon sinks and, eventually, to allow for international permit trades.

It is particularly important that both the electric generation sector and the industrial end-users of energy are included in the same permit system. To the extent that industries pursue non-utility generation options, the changes in emissions profiles will be reflected in permit demand and price. Likewise, an industrial electrification trend placing electric utilities under supply pressure will allow utilities to increase their product price to include the increasing price of permits for higher emissions. This ensures that deteriorating standards from shifting emissions between a regulated and an unregulated sector will not become a problem.

The final conclusion following from the discussion of source characteristics is the importance of including emissions from both self-produced and purchased fuels. For the most energy intensive industries, self-produced fuels represent a large and growing share of total fuel consumption. To exclude these would create a serious loop-hole in the emission policy. On the other hand, a policy should also be open to

innovative ways to reduce or capture CO_2. For example, if a company is involved in extensive reforestation or creates a carbon pond to reduce net emissions, the program should take this into account.

It must be emphasized again that much more research is required to generate reliable and comprehensive results on the carbon cycle. Allowing for the possibility of creating credits for carbon sinks would be a way to actively encourage such research efforts, and to ensure that these options are pursued if they represent the most economically attractive means of reducing net emissions.

Since most CO_2 emissions arise from combustion of fossil fuels, energy efficiency improvements are the main vehicle for emissions reductions. Although significant improvements have been made, there is still an untapped potential for energy conservation within the energy-intensive Canadian industries. In addition to further research to uncover and exploit these emission reduction options, more research is required to improve technologies for CO_2 stripping and to ensure safe and permanent disposal.

The most serious challenges for a CO_2 permit policy will be to design an adequate method of initial allocation and to ensure compliance with the regulations. The method of initial distribution will represent a prescription for wealth transfer, unless an auction system is used. The administrative burden of an auction-refund system should be weighed against the equity issues of various free distribution formulae.

The problem of enforcement will exist for any emission policy. Efficient enforcement requires, above all, adequate monitoring and reporting routines. In addition, the penalty for noncompliance must be large enough to deter emitters from ignoring the regulations. The problem of monitoring emissions by source remains. To evaluate monitoring options, it is necessary to undertake extensive analysis of the characteristics of CO_2 sources to determine levels of current emissions as well as the potential for emission variations due to changing operating conditions. The policy must also be designed to ensure that emitters have an incentive to facilitate easy and accurate monitoring of emissions. Source monitoring is particularly important with a permit system, since regulators are faced with the very significant problem of verifying the equivalence of traded emissions.

Finally, a permit policy should, from the outset, specify the duration of permits to establish confidence in the property rights

associated with emission trades. Failure to do this will create uncertainty and can seriously affect the incentive to trade. The expiration date must be set in accordance with a timetable for policy review and standard revisions, but could be staggered to allow for a smoother transition. The lifetime of permits should reflect a compromise between the administrative burden and economic impact of re-issuing permits, and the desirability of revising and adjusting emission targets.

Recommendations for Further Work

Some general conclusions with respect to further analysis and data collection follow from the case study. First, it is clear that permit trading can only constitute one of several policy initiatives to reduce greenhouse emissions.

- **A permit trading policy can only be a partial answer to the problem, since it cannot address all the sources of CO_2 emissions. Complementary policies must be pursued for the residential, commercial, transportation and small industrial sectors, keeping the total emission target in perspective.**

Secondly, there is currently little understanding of the economic costs and transfer payments that a permit system would entail.

- **The economic impact of a potential permit trading system must be extensively analysed prior to implementation. The equity issues in the system for initial distribution of permits are of particular importance in this respect.**

Much more work is required to gain a complete and detailed inventory of CO_2 sources. This is necessary both to delineate a potential CO_2 permit market and to further analyse monitoring and enforcement strategies.

- **If industrial sources wish the government to pursue the option of permit trading, they need to demonstrate the feasibility of this policy. This involves creating a source inventory and demonstrating their willingness and ability to monitor emission sources and comply with such a policy.**

To accomplish these tasks a cooperative, consultative process between citizens, industries and governments is crucial. If the goal of freezing, and eventually reducing, CO_2 emissions is to be met, it is in everyone's interest to minimize the economic costs involved. The feasibility of a permit trading policy must be subjected to further, extensive analysis. Any policy must be carefully designed to avoid a large administrative burden, unintended wealth transfers, and to ensure compliance. Considering the potential economic dislocation from any CO_2 policy, the promise of a least-cost solution, which is the basis of a permit system, is worthy of further examination.

Chapter 1

INTRODUCTION

The prospect of global warming is currently a dominating topic in environmental debates. The concern originates from the heat trapping properties of certain atmospheric trace gases, mainly carbon dioxide (CO_2), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), methane and tropospheric ozone. With growing atmospheric concentrations of these gases, the heat radiating from the earth is increasingly absorbed and retained in the lower atmosphere, producing the so-called greenhouse effect.

Designing policies to control air emissions is a complex and multi-faceted problem. For some emissions, the point of origin and timing of release are important determinants of the impact on air quality. Such emissions are commonly called non-uniformly mixed pollutants. Greenhouse gases, on the other hand, represent uniformly mixed pollutants. It is the aggregate atmospheric concentrations that determine the heat-trapping potential of these trace gases. Even when addressing uniformly mixed pollutants such as greenhouse gases, there may be interrelated and sometimes even conflicting objectives. In a broader context, the benefit of environmental policies must be weighed against the total economic costs including the consequences for regional disparities and a potential loss of international competitiveness.

This study does not address the broader issues, such as the international scope of the greenhouse problem, the imperative for action in developing and East European countries, and the potential damage to Canada's economy from unilateral initiatives. The purpose of this study is to examine a specific policy tool, emission permit trading, and the feasibility of adopting this tool for greenhouse emissions control in Canada. This does not imply an unconditional endorsement of permit trading policies, nor does it condone or challenge any federally or provincially adopted emissions goal.

The remainder of this chapter outlines the scientific controversy over the magnitude and immediacy of global warming, the role and sources of greenhouse gas emissions, and the current status of Canadian commitments and policies on global warming. Chapter 2

explains the theoretical background for permit trading as a policy option and Chapter 3 reviews the U.S. experience with this market incentive tool. Chapter 4 then analyses the potential for establishing a permit market in Canada using CO_2 emissions as a case study.

The rationale for choosing CO_2 as a case study for tradeable permits is outlined in detail in Chapter 4. At the outset it should be noted that, since man-made CO_2 emissions are directly related to combustion of fossil fuels, it is important to understand the likely impact on the energy sector in Canada of any policy designed to reduce CO_2 emissions. While a quantitative analysis of the economic impacts could not be carried out within the scope of this study, the effects are discussed in a qualitative framework. Attention is also drawn to the constraints imposed on the analysis by the current lack of data.

In controlling pollutants like greenhouse gases which are so wide-spread in our economy, it is important that the full impact of a policy be understood. This study is intended to provide a first step towards assessing the feasibility and understanding the consequences of implementing a permit trading system.

1.1 The Scientific Controversy over Climate Change

While the atmospheric changes caused by human activities are recognized, and the heat trapping properties of the greenhouse gases are well esablished, there is less consensus in the scientific community with respect to the ultimate effect a changing atmosphere may have on the earth's climate and the timing of that effect.

As proof of the warming trend, scientists point to an average global temperature rise of 0.3 to 0.6°C over the past century. This warming trend has been accompanied by a more than 10 percent increase in CO_2 concentrations between 1958 and 1989, from approximately 315 particles per million by volume (ppmv) to 350 ppmv.[1] It is estimated that mean sea levels have risen between 15 and 33 cm over the past century.[2] In addition, six of the warmest years ever recorded have occurred in the last decade, with both 1987 and 1988 setting heat records. The wide-spread drought in North America in 1988 served to focus the concern of the public on this issue.

Climate models indicate that a doubling of the concentration of greenhouse gases in the atmosphere could lead to an average temperature rise between 1.5 and 4.5°C, and predict that this will occur within the next 50 to 100 years if strict abatement strategies are

not implemented.[3] The consequences of such a global warming scenario include melting of polar ice, raising of the sea level by as much as 1.5 metres and widespread coastal flooding and inland droughts. Changes in soil moisture, growing seasons and significant climate variability would severely affect agriculture, leading in the worst scenarios to mass migrations, epidemics and starvation. These studies also indicate that regional climate changes will be most severe in the higher latitudes and that shifts in wind and rainfall patterns will exacerbate the climate variations. Such predictions have led to a call for immediate action to avoid an environmental catastrophe.

It was this kind of scenario that led the World Conference on the Changing Atmosphere held in Toronto in June 1988 to conclude that..."the ultimate consequences (of global warming) could be second only to nuclear war". This conference recommended a 20 percent reduction from 1988 CO_2 emission levels by 2005.[4]

Significant criticisms and qualifications accompany these predictions. The complex interactions of some important variables have been excluded from the climate models and existing data is as yet incomplete and unreliable. In particular, the role of the ocean as a CO_2 sink and the changes in oceanic circulations may serve to delay and retard global warming. In addition, increasing cloud-cover and changing reflective properties of clouds may offset the predicted temperature changes. The differences in evaporation and condensation patterns between tropical and temperate latitudes must be taken into account, and the temperature sensitivity of the hydrological cycle may also represent an important off-setting force to global warming.

As for the historical evidence of global warming, the changes are said to be small enough that we cannot rule out statistical noise and natural fluctuations. Less volcanic activity and variations in solar output are cited as natural causes of increased global temperatures, but the measurement and even the directional effect of such factors are disputed.

It may take ten to twenty years for scientists to generate enough reliable data to provide a prediction of climate change with a high degree of certainty.[5] While no conclusive evidence of global warming has been presented, it is commonly held that the potential for economic dislocation and human suffering that may result from global warming is so severe that preventive action is warranted. Considering that the concentration of trace gases has been building for the last

century, it is argued that a measure of global warming is by now unavoidable and we must act immediately to minimize the damage.[6]

On the other hand, scientists also caution against an over-reaction on the basis of inconclusive scientific evidence. If the case for global warming is found to be exaggerated, the cure could prove more difficult and costly than the disease. This would particularly be the case for developing countries where, without substantial transfer of advanced technologies and human and financial capital, environmental issues are now perceived as another hindrance in the struggle for acceptable living standards. Accommodating the needs of developing countries becomes the key challenge of a global strategy for greenhouse gas reductions.

The dilemma that faces policy makers in addressing global warming is really a case of risk analysis. The uncertainties related to the severity and timing of climate effects and the related costs to humanity must be weighed against the uncertain costs of abatement and adaptation, and the costs of delayed action. Delaying action will improve the scientific understanding and provide time for assessing economic costs and options. However, while the alternative actions and costs may be clarified over time, the number of viable options may actually be reduced and the costs of addressing the problem will rise as the concentration of emissions increases. If the environmental damage proves severe and irreversible, the effectiveness of relatively low-cost strategies for abatement may be insufficient.

The risk analysis approach suggests immediate adoption of policies that fall into two categories; the "no regrets" and the "insurance policy" options. No regrets policies are those that entail benefits to society even if the climate change prophesies do not materialize. This includes internalizing any known and well defined social costs of activities that lead to environmental degradation, for example, by eliminating wastes and improving energy efficiency. Insurance policies require a modest investment but offer high potential leverage against the effects of global warming. Investing in research to delineate options and reduce the uncertainties of decision making represent such insurance policies.[7] Beyond these "safe" approaches, strategies to deal with greenhouse gases will reflect a political judgement of the risks and uncertainties involved in this complex problem.

Despite the controversies, political actions on global warming appear to be forthcoming. **In light of the inherent uncertainty and the economic costs involved, it is important that**

policy tools be chosen carefully with a view to minimizing their economic impact while ensuring that the desired level of emission control is attained.[8]

1.2 Sources of Greenhouse Gas Emissions in Canada

While greenhouse gases have both natural and man-made (anthropogenic) sources, the relative importance of emissions related to human activities varies (see Table 1.1). Anthropogenic CO_2 emissions originate primarily from industrial processes and fossil-fuel combustion. Atmospheric CO_2 concentrations are also increased indirectly through deforestation and agricultural practices.

Sources of man-made CO_2 emissions can be analysed in accordance with the major fossil fuel consumption sectors. Residential and commercial sector emissions stem primarily from space and water heating requirements. In the industrial sector, fossil fuels are in addition used for direct heat in manufacturing processes and as boiler fuel. A portion of the electric utility sector uses thermal generation technologies, and the transportation sector consumes large volumes of petroleum products.

Globally, the principal sources of methane (CH_4) are natural and include wet lands (approximately 39 percent), rice paddies (19 percent), and livestock (11 percent). Large uncertainties are attached to these numbers.[9] Although these emissions are termed "natural", they are clearly related to human activities such as land use and agriculture. Important sources of methane emissions in Canada are coal mines, petroleum exploration and production activity, and fugitive emissions from landfill.

CFCs are chemical products and as such entirely man-made. These products are used in the manufacture, testing, maintenance and operation of a range of products, primarily foams, aerosols, refrigerants and solvents.

Nitrous oxide is formed by the combustion of fossil fuels and is released from fertilizers. An N_2O molecule contributes 200 times the warming effect of a molecule of CO_2.[10]

Tropospheric or ground-level ozone (O_3) is a particularly difficult gas to predict and control, because it is formed in a chemical reaction in the air rather than emitted from a process. Ozone is

TABLE 1.1

MAJOR GREENHOUSE GASES AND THEIR CHARACTERISTICS

Gas	Atmospheric Concentration (ppm)	Annual Increase (%)	Life Span (yrs)	Relative Greenhouse Efficiency (CO_2=1)	Current Greenhouse Contribution (%)	Principal Sources of Gas
Carbon Dioxide (Fossil Fuels)	351.3	0.4	x[a]	1	57 (44)	Coal, Oil, Natural Gas,
(Biological)					(13)	Deforestation
Chlorofluoro-carbons	.000225	5	75-111	15,000	25	Foams, Aerosols, Refrigerants, Solvents
Methane	1.675	1	11	25	12	Wetlands, Rice, Fossil Fuels, Livestock
Nitrous Oxide	.31	0.2	150	230	6	Fossil Fuels, Fertilizers, Deforestation

SOURCE: Christopher Flavin, *Slowing Global Warming: A Worldwide Strategy* (Washington, D.C.: The Worldwatch Institute, 1989), p. 13.

[a]Carbon dioxide is a stable molecule with a two to four year average residence time in the atmosphere.

produced from nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in a reaction that depends on sunshine and temperatures.

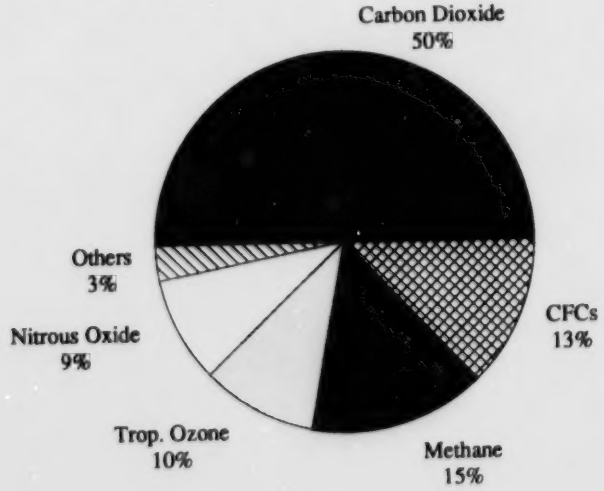
In terms of volume, CO_2 is by far the most important of the greenhouse gases, but the potency, longevity and the significant growth rates of the other trace gases must be taken into account when comparisons are made. Figure 1.1 shows the relative importance of these gases when the different heat-trapping capabilities have been accounted for. It indicates that CO_2, in its current proportion to the other gases, is responsible for approximately 50 percent of a warming effect. Some studies estimate that the relative contribution of CO_2 could increase to over 70 percent over the next century,[11] although the direction of such trends is a disputed issue. Methane is shown to contribute approximately 15 percent, CFCs 13 percent and tropospheric ozone and N_2O, 10 and 9 percent respectively.

Most of the greenhouse gases other than CO_2 are also targets for different environmental concerns such as stratospheric ozone depletion and acid rain. Due to the serious health effects, ground level ozone is also targeted as a separate pollutant. These emissions can, to a greater extent, be subjected to direct control through product substitution or investment in control technologies that reduce their formation in the production processes. With CO_2 this type of technology solution is not feasible. Remaining alternatives are to reduce fossil fuel use through energy efficiency and fuel switching measures, or to strip CO_2 from the flue gas and deposit or use it elsewhere. The most interesting alternative in this respect may be to inject CO_2 into oil and gas wells, either for storage or as an enhanced oil recovery technique.[12] In general, more research is required to complete our understanding of the carbon cycle. Given better understanding and reliable data, the development of carbon sinks may be a viable alternative in a CO_2 control strategy.

Since CO_2 is the largest and most wide-spread of the greenhouse gases, and has a direct link to production activities and energy use, it will receive special emphasis in this study. Chapter 4 shows how the characteristics of at least some of the sources of CO_2 may make emission permit trading a feasible policy choice for controlling these emissions.

In an international context, Canadian CO_2 emissions are small, representing approximately 2 percent of the world total. On a per capita emissions basis Canada ranks fourth in the world behind East Germany, the United States and Czechoslovakia. While such

Figure 1.1
Radiative Gases and Their Relative Contribution to Global Warming



SOURCE: Canadian Coal Association.
House of Commons Briefing,
December 14, 1989.

international comparisons serve to place the problem in perspective, they are too simplistic to form the basis for policy analysis. Factors such as climate, geography, population density, resource base and industrial structure are the key determinants of energy use and must be understood and accounted for when making international comparisons of energy efficiencies or emission profiles.

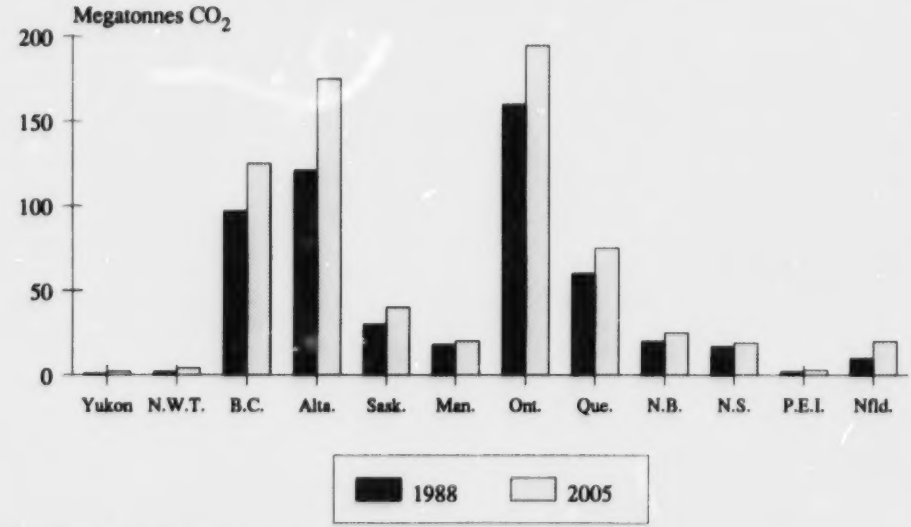
It is of greater importance in an international context to isolate and understand the most rapidly growing sources of CO_2 emissions. In the future, the greatest growth in emissions is expected to come from developing countries in Africa, South America and Asia and from Eastern Europe. The global nature of this problem and the relative insignificance of Canada's emissions, as well as concern for deteriorating international competitiveness of the policy-targeted industries, has fueled resistance to unilateral Canadian initiatives.[13]

Within Canada, the regional differences in CO_2 emissions are also marked. This is primarily due to the regional differences in electricity generation technologies. As Figure 1.2 indicates, Alberta ranks second behind Ontario in terms of total emissions, despite a much smaller population and industrial base. On a per-capita basis Alberta becomes the largest CO_2 emitting province. This is primarily due to the reliance on coal-fired electric power plants in Alberta, while provinces like Quebec, British Columbia and Manitoba rely heavily on hydroelectric generation, and Ontario on its substantial nuclear capacity.[14] Again, per capita comparisons are simplistic, since factors such as population size and density, resource base and industrial structure determine the provincial emission profiles.

Figure 1.3 indicates both current and projected sources of CO_2 emissions on a sectoral basis in Canada. The transportation sector is, and will continue to be, the largest source of CO_2 emissions. It is predicted that over the next fifteen years emissions from electric utilities will surpass CO_2 emitted by the industrial sector, unless substantial changes take place in the generation mix in this sector.

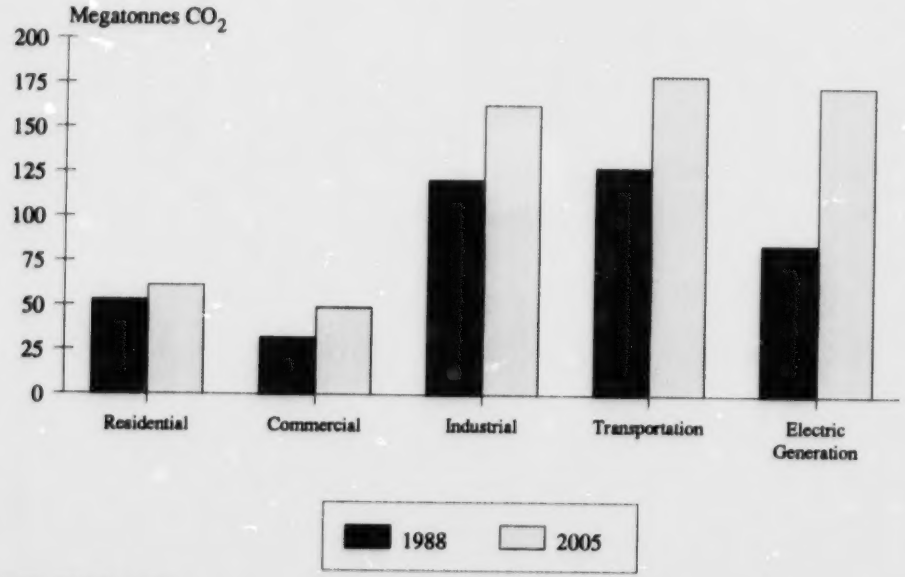
It is important to note the significantly different characteristics of the three main sources of CO_2 emissions. While the industrial and electric utility sectors are both characterized by relatively few, large, stationary sources of emissions, the transportation sector consists of a very large number of mobile sources. Furthermore, the electric utilities are primarily publicly owned and/or regulated, while the industrial sector in Canada is predominantly privately owned.

Figure 1.2
Carbon Dioxide Emissions by Province and Territory



SOURCE: Report of the Federal/Provincial Territorial Task Force on Energy and the Environment, April 2, 1990.

Figure 1.3
Projected Carbon Dioxide Emissions
by Sector



SOURCE: DPA Group Inc.

These differences have important implications for the design of effective and efficient environmental policy measures and will be further explored in Chapter 4.

1.3 Canadian Initiatives and Commitments to Reduce Greenhouse Gas Emissions

Serious international discussion on the global warming issue was initiated by the National Academy of Science's report, which led to the first World Meteorological Conference in 1979. During the early 1980s, a United Nations World Commission Concerning Environment and Development was established, producing in 1987 the "Brundtland" Report, "Our Common Future." The recommendations from the Toronto Conference in June 1988 provided considerable momentum for the global warming issue, and subsequently the Intergovernmental Panel on Climate Change (IPCC) was established in November 1988 under the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The IPCC report, tabled at the Second World Climate Conference in Geneva, Switzerland in November 1990, provides the background information that might serve to develop a future convention on climate change. It is hoped that the resulting negotiations will produce a framework treaty for the Second United Nations Environment and Development Conference scheduled for Brazil in 1992.[15]

Canada has conducted an inquiry into energy related measures to reduce CO_2 emissions through the Federal/Provincial/Territorial Energy Ministers' Task Force on Energy and the Environment. The task force first reported to the Canadian Energy Ministers in August 1989, stating that a 20 percent reduction from 1988 levels by 2005, as recommended by the Toronto Conference, should be considered an illustrative target rather than a formal goal. The Energy Ministers concluded that: "National and regional initiatives that reduce emissions and that are socially, economically and environmentally sound should be pursued".

In April 1990, the Task Force presented a second report stressing the differences in potential for reductions of CO_2 emissions across the country. The report concluded that a 20 percent reduction in emissions by 2005 would cause significant economic dislocation and is not a practical target.[16] At the Bergen conference convened in May 1990, the federal environment minister announced that Canada would work to stabilize CO_2 emissions at the 1990 level by the year 2000.

This position was reiterated at the Second World Climate Conference in Geneva, Switzerland in November 1990.

The Montreal Protocol, signed in 1987, commits Canada to reduce CFC consumption by 50 percent of 1986 levels by 1999. Substitutes for CFCs are available and more are expected to come on the market over the next five to eight years.[17] It has been estimated that by the year 2000, substitutes will have been found for 85 percent of the current CFCs and halons. Canada plans to exceed the Montreal Protocol commitment and has announced an intention to eliminate all CFCs completely as soon as safe substitutes are available, indicating the year 1997 as a target for a CFC ban.[18]

A unique problem with CFC emissions is that CFCs used to produce products currently in service, such as refrigerators, will not result in emissions into the atmosphere until those products have been discarded, which may lead to a delayed effect of several years. This creates a need for measures to recover and safely destroy CFCs which are "banked" in products now in use.

Fugitive methane emissions are, by their nature, difficult to measure and control, but some efforts have shown promising results. The petroleum industry has committed substantial resources to scrutinize and, where possible, eliminate the sources of fugitive methane. For large landfill sites, economic recovery of methane is a possibility, although little recovery is currently practised. Limited methane recovery from waste water treatment plants has also proven economical in some cases.

1.4 Summary

Human activities are changing the composition of the earth's atmosphere at an unprecedented rate. While there is significant scientific controversy over the magnitude, timing and regional impacts of global warming, there is consensus that the greenhouse effect can be attributed to certain trace gases in the atmosphere.

There are a host of gases that contribute to the greenhouse effect. CFCs, N_2O and methane have a much greater warming potential than CO_2 on a molecule by molecule basis, but:

- **the large volumes involved make CO_2 the single most important of the greenhouse gases. CO_2 is responsible for approximately 50 percent of the potential warming of the atmosphere.**

Most of the other greenhouse gases are also targeted for other environmental reasons such as stratospheric ozone depletion, acid rain and tropospheric ozone formation. Carbon dioxide is only a target as a greenhouse gas and, in addition, control technologies cannot be easily and cost effectively applied to reduce CO_2 formation in the combustion of fossil fuels.

- **Large-scale reductions in CO_2 levels will require costly, fundamental changes both in production processes and consumption patterns.**

There are many unknown factors related to the life-cycle of CO_2 emissions. The carbon cycle includes delayed effects and carbon sinks that may offer opportunities to offset rising emission levels.

- **It is important to distinguish between net and gross carbon emissions from a source. However, the present uncertainty with respect to the potential offsetting force of carbon sinks makes measurement of net carbon emissions a difficult proposition.**

In Canada, the largest sources of CO_2 emissions are fossil fuel combustion in the transportation, industrial and electric utility sectors, and in some industrial processes. The very different characteristics of these sources of CO_2 emissions must be noted, in terms of size, number of units, market structure and combustion technologies involved. The resulting regional diversity of emissions within Canada is an important consideration in formulating an emission policy.

- **Recognizing the wide-spread nature of CO_2 emissions and the divergent characteristics of emission sources, a practical policy response must consist of several initiatives in a "policy package" as opposed to a single "best" policy option.**

As for the status of international and national initiatives to reduce CO_2 emissions:

- The draft report by the IPCC will set the stage for further international negotiations on strategies and commitments for global greenhouse gas emission reductions. A treaty might be ready for signature at the Second United Nations Environment and Development Conference in 1992.

- Several industrial countries, including Canada, have adopted an interim target of stabilizing CO_2 emissions

at the 1990 level by the year 2000. Some countries have gone further and committed to 20 to 35 percent reduction targets in this time frame.

Climate change is a global problem. The issues related to greenhouse gas emissions must be analysed and addressed in an international context to ensure effective and efficient responses while accommodating the needs of developing regions. It is also important to avoid creating competitive distortions in international trade when implementing a domestic emissions policy.

While recognizing the global nature of the problem, this study does not attempt to address these broader issues. Rather, the report assumes that an internationally compatible domestic emissions target is set and, hence, proceeds to examine the issues related to implementing a domestic permit trading policy.

Footnotes

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[2]Hatch Associates Ltd., *CO_2 Emissions: Perspectives and Future Options for Canadian Electric Utilities and the Coal Industry*, Vol. 1, Report to the Canadian Electrical Association (Toronto, Ontario: Hatch Associates, December 1989), p. 2.

[3]Dr. Stephen Schneider, Head, Inter-disciplinary Climate Systems Program, National Centre for Atmospheric Research, speaking to the "Parliamentary Forum on Global Climate Change," April 23 and 24, 1990 (Ottawa, Ontario: Supply and Services, 1990).

[4]Proceedings of the World Conference on the Changing Atmosphere, Toronto, Ontario, June 1988.

[5]Dr. Stephen Schneider, speaking to the "Parliamentary Forum on Global Climate Change."

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[7]John P. Holden, "Energy in Transition," *Scientific American*, Vol. 2, September 1990.

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[9]U.S. Department of Energy, *A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Change, Volume 1* (Washington D.C.: U.S. Department of Energy, October 1989), pp. 1-3.

[10]Ibid., pp. 1-3.

[11]U.S. Department of Energy, *Energy Efficiency and Global Warming* (Washington D.C.: U.S. Department of Energy, 1989).

[12]Alberta Department of Energy, *Carbon Dioxide Emissions in Alberta 1988-2005*, A Report to the Intergovernmental Task Force on Energy and the Environment (Alberta: Alberta Department of Energy, March 1990), p. 10.

[13]Federal/Provincial/Territorial Energy Ministers' Task Force on Energy and the Environment, *Report to the Federal/Provincial/Territorial Conference of Ministers of Energy* (Kananaskis, Alberta: Federal/Provincial/Territorial Task Force on Energy and the Environment, April 1990).

[14]The DPA Group Inc. *Study on the Reduction of Energy-Related Greenhouse Gas Emissions, Vol. I*, prepared in association with CH_4 International Ltd., Monenco Consultants Ltd., RCH/Hagler, Bailly Inc. and Steven G. Diener and Associates Ltd. (March 1989).

[15]Tahao Tomitate, "Political Evolution of International Arguments on Global Warming," *Energy in Japan, Special Edition* (Japan, The Institute of Energy Economics, February 1990).

[16]Federal/Provincial/Territorial Energy Ministers' Task Force on Energy and the Environment, *Report on Reducing Greenhouse Gas Emissions* (Ottawa, Ontario: Federal/Provincial/Territorial Task Force on Energy and the Environment, August 1989).

[17]Abt Associates of Canada, *An Assessment of the Economic Impacts of a Ban on the Use of Rigid Foams Containing Chlorofluorocarbons*, a project report prepared for Socio-Economic Analysis Division, Environment Canada (Ottawa, Ontario: Environment Canada, October 1989).

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Chapter 2

THE THEORY OF PERMIT TRADING AS A MARKET INCENTIVE POLICY

The potential costs associated with greenhouse gas emission control are such that any environmental policy designed to deal with the problem will be politically sensitive and controversial. A need exists for a regulatory mechanism that will incorporate the environmental costs (and benefits) of economic activities into the decision making processes of producers and consumers. This chapter outlines the theory of permit trading in the context of environmental economics. This theoretical background provides the basis for understanding the conditions necessary for establishing a successful trading program.

2.1 Market Failure and Economic Externalities

The source of the problem of environmental abuse, or overuse of environmental resources, is commonly viewed in economic theory as a failure of the market economy to recognize and internalize the costs imposed on the environment by human activities. Unintended or non-internalized costs (or benefits) which accrue to individuals from the actions of another party are referred to as externalities. In the case of environmental emissions, negative externalities arise whenever the production or consumption activities of some agents influence the quality and quantity of environmental resources available to others.

Using air pollution as an example, pollution of the air from one factory's production activity affects the consumption of clean air for all other consumers and producers. The polluter is not required to pay for these costs imposed on others as long as clean air is considered to be a free good.[1]

A recommended solution to such externalities from the point of view of economic theory is to create a market for the externality by assigning property rights to the over-used commodity, in order to force compensation to the commodity owner and/or reduce consumption of that commodity.[2]

In the case of air pollution, assigning property rights is clearly a difficult issue. Not only is it impractical to allocate quantities of clean air to individuals or companies, but air pollution is characterized as an undepletable externality. In other words, consumption of polluted air by an individual does not decrease the quantities of polluted air that others are exposed to.

In response to this problem, economic theory has devised a set of market-based policy tools to control the excessive use of environmental resources and internalize the external costs to society. Emission permit trading is a practical policy tool derived from the economic theory of market incentive policies.

2.2 The Theory of Permit Trading

The use of markets for tradable emission permits to control levels of pollution confronts directly the problem of market failure. We cannot determine the ownership of air resources on the basis of private property rights. We have no way of dividing up the use of the air and, consequently, the ability to use this resource as a source of waste disposal has historically been allocated among users at a price of zero. Accordingly, industry and consumers alike have used our source of unpolluted air as though it were a free good of unlimited supply, when in fact it is a limited resource characterized today by increasing scarcity.

2.2.1 Defining the Optimal Level of Emissions

Given that the problem of environmental abuse is attributed to the lack of well defined rights associated with the capacity of our atmosphere to absorb waste, it would seem natural to suggest that a potential solution might involve the establishment of correctly defined property rights to promote the efficient allocation of this vital resource through the marketplace. In response, economists have promoted the idea of using artificially created markets which extend private ownership to the license to pollute environmental resources.

In the most general application of such a market system, those who wish to pollute and those who wish to preserve the environment can compete within a market framework for the saleable licenses associated with the limited capacity of the environment to absorb the pollutant. The acquisition of a license, if used, entitles the owner to release a specified amount of pollution into the environment each period. On the other hand, by holding the license unused, the

owner can prevent the same amount of pollution from occurring, thus preventing further degradation of our environment. The level of pollution is then determined by the distribution of licenses, or emission permits, among those wishing to pollute and those wishing to preserve environmental quality.

Ideally, the benefits of such an approach lie in its ability to achieve a socially optimal use of environmental resources, and to provide those exposed to the effects of the pollution with a means of compensation through the market. It is highly unlikely, however, that such a market could provide a socially optimal level of pollution-free air, given the public nature of the resource involved. Specifically, the owner of an unused license to pollute cannot exclude others who have not paid for the license from sharing in the consumption of its benefits, namely the benefits provided by clean air. Since the full benefit provided by the purchase and holding of a permit cannot be realized by the owner, an insufficient purchase of licenses by those wishing to prevent environmental degradation would likely occur. Consequently, the efficiency criteria for resource allocation, which requires that the pollution licenses be distributed amongst market participants such that the marginal costs and marginal benefits of controlling pollution are equated, is difficult to achieve.

Achieving socially optimal use of society's environmental resources can be viewed as a two step process. The first step consists of defining the desired level of environmental control. In theory, this is achieved by equating society's marginal benefits to the marginal costs of control. A quantity of emissions is thereby defined for which the cost of using or degrading the last unit of a resource is exactly equal to the benefits derived from its use. In reality this setting of environmental standards is wrought with uncertainty with respect to both the effects of environmental degradation and the costs of control. The benefits of environmental preservation are particularly contentious and difficult to measure. Market processes cannot be relied upon to achieve a socially optimal level of control. The public nature of environmental amenities requires that any mechanism which attempts to provide acceptable levels of pollution-free resources must somehow estimate the demands for these resources, which are not likely to be recognized in a market setting.

Traditionally, this role has been assigned to governments whose task has become one of establishing, through a political process, limits to aggregate emissions necessary to achieve a desired air quality

and ensuring that these limits are adhered to. Once a standard has been established, the second step is to distribute emission control responsibility among the major sources of emissions.

2.2.2 Achieving Emission Control at Minimum Costs

The command and control approach to regulation has been the prevalent policy tool used by government authorities in an effort to limit polluting emissions and to maintain environmental quality standards imposed by the state. This approach distributes control responsibility among the sources of discharge by assigning separate emission standards, referred to as ceilings, for each point of discharge. Such standards are most simply set by allocating emission control equally among all sources (i.e., by imposing a restriction specifying a maximum rate of discharge on all sources). Standards are usually uniform, at least for broad classes of sources. This uniformity can result in very different marginal costs of emission control between sources. In forcing each source to control up to a certain level of emissions, some high-cost solutions to emission control are implemented while other low-cost sources may remain unexploited.

The potential for large cost penalties associated with the regulatory approach has led researchers to examine alternative means of allocating control responsibility through the establishment of an emission permit system. Such a system involves the assignment of private ownership to environmental resources through the distribution of a limited number of permits to discharge pollutants into the air or water. It then relies on the incentives of the market to achieve aggregate emission target levels in the most cost-effective manner. Market based incentive systems give the emission sources the flexibility to reallocate control initiatives, so that low-cost sources control relatively more, and high-cost sources relatively smaller quantities of emissions.

The operation of an emission permit system requires that a control authority determines the desired level of aggregate emissions in the atmosphere and, accordingly, issues an initial offering of licenses to emitting sources such that emission levels remain equal to or below that level. In addition, the control authority is required to organize a formal market for the trading of emissions, and enforce the emission limits by imposing noncompliance constraints. Each emission license defines the allowable total of emission discharge for the owner over a specified period. Given the initial offering of licenses,

profit maximizing firms in the economy would engage in trading of licenses so as to minimi .e the costs imposed upon them by emission constraints.

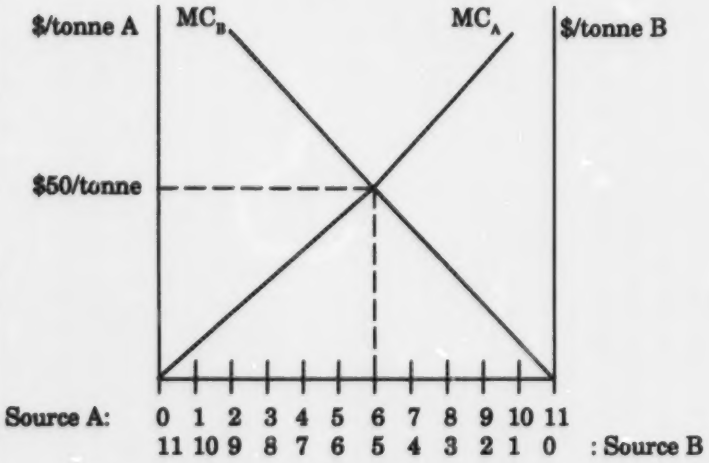
In market equilibrium when all sources are operating according to conditions for cost minimization, the marginal cost of pollution control is equalized across all sources. Intuitively, this is a reasonable result, in that an incentive will certainly exist for sources with relatively low marginal costs of control to increase their level of control and to sell excess emission permits, the value of which should exceed additional control costs incurred. Similarly, sources with relatively high marginal costs of control will find it less costly to purchase emission permits than to install additional control equipment.

Consider the example where Source A has marginal control costs of $100 per unit and Source B has marginal control costs of $25 per unit. If Source B purchases an emission permit from Source A for a price which falls between these two values, both sources will achieve a net benefit. They will both be able to reduce their total commitment of resources to emission control (including licence purchase). When all such trading opportunities have been exhausted, the marginal costs of control will be equalized across all sources and the cost-effective allocation of permits is achieved. All potential for control cost reductions has been eliminated and the total cost of pollution control across all sources is minimized.

According to Figure 2.1, which illustrates this example, trading opportunities will exist until the marginal costs of control are equated at the point where Source A controls six units of emissions and Source B controls five. The total costs of control, represented by the area under the cost curves, is clearly minimized at this point.

The diagram also illustrates that in a market equilibrium, the marginal control costs of each source will be equal to the equilibrium market price for permits, which in this case is $50 per tonne of emissions. This price represents the control cost savings which could be realized if the emiss:on constraint was relaxed by one unit. The price prevailing in a competitive permit market, therefore, reflects the difficulty firms experience in meeting the imposed standard. The greater the constraint imposed, the higher will be the equilibrium price and, accordingly, sources will increase their levels of control to equate rising marginal control costs with a higher market price.

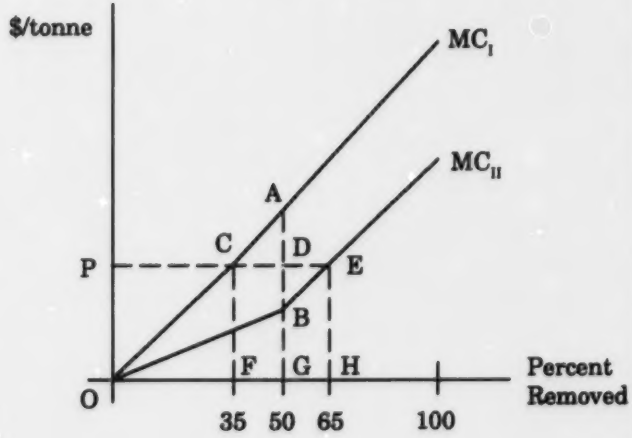
Figure 2.1



MC_A: Marginal Cost of Control for Source A.
MC_B: Marginal Cost of Control for Source B.

Total emissions controlled: 11 tonnes
Source A eliminates 6 tonnes
Source B eliminates 5 tonnes

Figure 2.2



MC_I: Marginal Cost of Control for High Cost Source.
MC_{II}: Marginal Cost of Control for Low Cost Source.

Both the low and the high cost source will derive benefits from trade, incurring lower costs under a free permit distribution system than under a uniform regulatory control approach. Figure 2.2 illustrates this. Note that the marginal cost curves here are for percentage reductions rather than absolute quantities as in Figure 2.1, and that, for simplicity of exposition, the example assumes equal volumes of emissions from both sources. Both sources are initially allocated permits equivalent to half of their current emissions. The distance between the two marginal cost curves with 50 percent reduction in emissions from both sources, from point A to point B, illustrates the incentive to trade. In a competitive market, a permit price "P" would evolve and the low-cost source would remove 65 percent of its emissions, trading their surplus permits to the high-cost source which would only remove 35 percent.

The total cost to the high-cost source is then the area OCF for the cost of control plus area CDGF for permit purchase, compared to area OAG under a regulatory system. Net cost savings for the high-cost source is illustrated by the triangle ADC. The low-cost source will incur control costs of OEH, but receives permit payments of DEHG, leaving a net gain from trade of DEB compared to the regulatory system.

The theory of permit trading illustrates how both high- and low-cost sources can benefit from a trade. However, the distribution of benefits is clearly dependent on where in the gap between their marginal costs, the permit price is established. To the extent that trading takes place in a competitive market where all the sources exhibit well-behaved, continually rising marginal cost curves, the distribution of benefits would presumably be fairly equal. In reality, these curves are more likely to resemble step-functions, in which case the permit price function can become discontinuous. The actual permit price is therefore likely to fluctuate, making it difficult to establish the relative benefits from trade. In this kind of market, the bargaining power of individual sources becomes the most important factor in determining their benefits of trade.

A qualification must be made with respect to the assumption of fluidity of capital investments. To the extent that the optimal solution requires all sources to undertake additional investments in control equipment, the trading assumptions are not unrealistic. However, it is unlikely that firms will find it optimal to reverse previous investments in emission control equipment.

Capital expenditures are commonly considered "sunk costs" and the losses associated with equipment down-time and the need for additional capital expenditures make it hard to imagine a situation where the plant management would find it optimal to de-invest in control equipment in the short-run. This reversal of control efforts is only realistic to the extent that emissions are controlled by adjustments in operating procedures or by changing inputs of materials or labour. Alternatively, emissions control reductions can be viewed as a long-run phenomenon, but again, it would likely require substantial incentives, in the form of high gains from permit sales, to induce a firm to de-invest in control capital. In long-run decisions, firms must also take into account uncertainty with respect to future permit requirements. If standards are expected to tighten over time, or if the firm expects its emissions to increase, it is unlikely that the firm would reduce its current level of control.

2.2.3 Allocation of Emission Permits

The main advantage of a system of tradeable permits lies in its flexibility, enabling the market to achieve a certain environmental standard with the lowest cost of compliance and minimal interference, irrespective of the initial allocation of emission permits. However, the method of permit distribution is an important consideration. By placing value on a previously free resource and creating rights to this resource, the authorities are, in essence, creating wealth. The system for permit allocation will therefore determine both the total financial burden imposed on emitters and how this cost burden is distributed among the sources of emissions. Any costs incurred for the initial purchase of permits are referred to as transfer payments, since these expenditures in turn represent revenue for the public authorities. Costs incurred in the actual trading of permits are likewise transfers between emissions sources, rather than net costs.

There are two relevant approaches to allocating permits. Authorities can either give them away free of charge or sell them through an auction process. Theoretically, a third approach is conceivable, namely vesting the ownership of emission permits with the polluting industries and requiring public authorities to purchase permits in order to reduce emissions. However, both the public expenditure involved and the transfer of resource ownership to the private sector make this approach politically untenable.

In addition to questions related to the economic impact and equity of transfer payments, the potential and incentive for market

manipulation will differ by permit allocation scheme, and this possibility must also be considered. A related point is the possibility of creating incentives to adjust baseline emissions if permits are expected to be allocated based on current emissions levels at some future date. This issue will not be discussed further in this report, but should be kept in mind when developing an allocation system.

2.2.3.1 Auctioning Permits

With an auction system, emitters are required to pay for the release of emissions. Initially, then, the entire cost of achieving a certain air quality is carried by the owners of the emission sources. Through commodity price increases, adjustments in wages and employment, and demand for other factor inputs, the economic impact of a cost increase will spread to the industry consumers, employees and suppliers. The extent to which an industry will be able to recover these costs will depend on its ability to increase commodity prices and adjust the production process.

This is one reason why rate-regulated industries, such as electric utilities, have been prime targets for air quality regulations. The perception is that since all production costs are automatically passed on to consumers through the rate structure, the industry is not made to carry large cost burdens, nor are some utilities placed at a competitive disadvantage since utilities are commonly in a monopoly position in their respective markets. The costs are distributed widely to all consumers, limiting the impact on any single sector. Consequently, it has been a politically easy sector to concentrate on imposing emissions regulations. The fact is, of course, that increasing the price of electricity will reduce quantities demanded. Electric utilities are subject to the constraints imposed by their respective markets just like any other producer, and unilateral policies for the electric utilities sector are not without a cost penalty.

A single price auction system may require that each emitter submit a binding demand schedule for permits, specifying the quantity of permits each emitter is willing to purchase at given prices. By aggregating across all the emission sources, a permit demand schedule for the entire market can be constructed. The equilibrium permit price is then found as the price for which the aggregate demand for permits corresponds to the quantity of permits to be allocated. All bidders who qualify for permits are ensured that they will receive the quantity desired at less than or equal to the price specified in their bid.

Studies have shown that the financial burden associated with the purchase of rights may be so great that total compliance costs for companies, including the transfer payments to the government for initial purchases of permits, can actually exceed the costs of controlling emissions under a regulatory approach which requires uniform standards for all sources.[3] Because of the substantial costs involved, the auctioning of permits may create a potential for manipulation of the permit price by bidders, especially if there is a limited number of market participants. This can be overcome by employing special auctioning systems, referred to as "incentive compatible auctions", which are designed to discourage manipulative behaviour.

Using simulation techniques, the costs of compliance for two case studies under the uniform regulatory approach, free permit distribution, single price auction system with no market manipulation, and an incentive compatible auction system were examined and reported in the U.S.[4]

The first case study examined was designed for phosphorous control for 53 municipalities in the Lake Michigan Basin. Minimum control cost, excluding permit purchases for the three permit systems, was $3920 per day, compared to $4880 per day under the regulatory approach, illustrating the potential cost savings of a market-based system. However, when the cost of permit acquisition is added, the single priced auction would add $5940 per day, and the incentive compatible approach $4960 per day, bringing the total cost of compliance with permit auctions well above the costs in a regulatory approach.

The second case study examined eleven sources of emissions into the Willamette River in Oregon. Again, the regulatory control costs of $9840 per day exceeded the market-based minimum costs of $8500 per day. However, the auctioning of permits would add $2300 and $1600 per day for the single price and incentive compatible systems, respectively.

The substantial financial burden placed on emitters when they are required to purchase permits can be avoided by employing a transfer-neutral allocation system. This can either take the form of an auction with a lump-sum refund to bidders, or free initial distribution. Studies suggest that under competitive conditions, free initial allocation is the preferred option, but that an auction-refund procedure can provide the same distributional effects as free allocation, while overcoming problems of strategic manipulation of the permit market.[5]

2.2.3.2 Free Initial Allocation of Permits

The chief difficulty with a free distribution system is determining a fair basis for the initial allocation. Any formula developed for this purpose constitutes a prescription for transfer of wealth. It must embody some concept of equity and therefore requires a political judgement.

The way to minimize, if not avoid, controversy over the choice of allocation method would be to allocate in accordance with the marginal costs of control, so that control burdens are equalized across sources. However, this is not a trivial task, and in a sense it preempts one of the main advantages of a permit trading system, namely reducing information required by control authorities while minimizing the costs of compliance. In order to allocate permits so that the marginal costs of compliance are equalized across all sources, the information burden would be equal to that of a regulatory system which, given this information, could achieve the same minimum cost of compliance as a permit system.

It can be argued that a permit system retains the advantages of flexibility over time. It will continue to provide emission control at minimum compliance costs even as economic conditions change, industries grow or contract, and new technologies are developed. Also, the cost of making a mistake in the allocation of permits can be corrected in the market at a lower cost to emission sources if permit trading is allowed, rather than sources being made to comply with a miscalculated standard.

The problem remains, however, of obtaining the detailed, accurate and reliable costs of compliance by source required for such an allocation. Short of an auction system that forces the individual sources to reveal their marginal costs of control in their respective bids, it is difficult to imagine a way to efficiently obtain this information.

To summarize, a free allocation method requires some formula for distribution designed with the clear understanding that any allocation method that results in wealth transfer between sources represents a political value-judgement as to which industries or regions "deserve" such a transfer payment. There is no objective or neutral way to design a formula for permit allocation as long as the initial distribution provides an incentive for wealth transfer.

Any emission policy requires information on current emissions for the purpose of assessing the problem, setting a total emission target, and monitoring and enforcing the policy. In the case where existing levels of emissions are environmentally acceptable, but any further growth in emissions must be curtailed, initial allocations can be based on current emissions by source. The assumption is, then, that all the sources are currently in an equilibrium situation, having adapted their production processes to the current state of regulations. If there are no current restrictions on emissions, then all sources should have a marginal cost of control of zero reflecting that no control measures are in place. In other words, all emissions sources are assumed to be starting from a position with equal marginal costs of control, which may be zero if no regulations currently exist. To the extent that this assumption is fulfilled, allocation of permits up to current emissions levels will not induce any initial wealth transfer.

The design of an allocation formula will depend on the characteristics of both the pollutant and the sources involved. Chapter 4 lists some options for initial distributions of CO_2 permits. **The main conclusion with respect to allocation is simply that given the political nature of the problem, the choice of formula must be subject to extensive analysis to clarify the economic impact. Further, the analysis should clearly outline and justify the political decisions involved.**

2.2.4 Non-Competitive Behaviour

A system with free distribution of permits may be incentive incompatible for two reasons. First, just as for auction systems, the potential for strategic behaviour by emitters to manipulate initial allocations of permits may exist. Source owners may have an incentive to report incorrect values for emission rates or marginal control costs. Clearly, a market system designed to achieve specific environmental goals will be unsuccesaful if it is based upon information voluntarily submitted by market participants who, in their self interest, report such information incorrectly. This is the problem of determining correct benchmarks for emissions.

Secondly, when only a small number of buyers or sellers exist, manipulation of the exchange of permits may occur. Specifically, if certain market participants are able to exert market power, either sellers' receipts will be higher than under a perfectly competitive setting or buyers' payments will be lower. It is, therefore, important to

consider whether a sufficient number of buyers and sellers exist in the market so that price-taking behaviour will be encouraged.

For example, if only a few sources are responsible for a high proportion of emissions, these sources may have the ability to charge higher than competitive prices by restricting the number of permits placed on the market (e.g., through collusive or cartel behaviour). Consequently, they will receive windfall profits on the sale of their permits, and prevent the achievement of an efficient allocation of control. The substantial fluctuation in the sale price of permits which may result from these circumstances may interfere with the ability of sources to make efficient control choices. The consequence of an imperfectly competitive market might also include the prohibition of growth if major permit holders collude to keep new firms from entering the market. An oligopolistic or monopolistic permit market could serve as an effective barrier to entry for new emission sources.

Generally, the definition of geographic boundaries for a market in emission licenses and the specification of which sources are to be included in the market are variables which may be adjusted to improve market structure and for the purpose of regional development. Problems will most likely arise in markets where the number of emission sources is very small, and where new sources trying to relocate within the market air-shed have no alternative locations to choose from.

2.2.5 Intertemporal Allocation

The problem of intertemporal allocation of pollution control responsibility must also be addressed. Under ideal circumstances, all sources of emissions would have perfect foresight with regard to prices and future demand for emission permits and would, therefore, make optimal control investment decisions. However, reality does not reflect these ideal circumstances. The lack of perfect foresight makes it more likely that existing emitters will either underestimate future prices and demand for permits and subsequently underinvest in pollution control technology or, alternatively, overestimate future demand for permits and overinvest in control equipment.

In the case where all emitters underinvest consistently through time, problems could arise for new industry players hoping to establish themselves in the marketplace. Specifically, existing emitters who have underinvested in control options and are operating on their short run cost of control curves have little flexibility in the

control options available to them in the near term. Although higher than expected prices for emission permits would provide incentive for them to increase their level of control and sell emission permits to new sources, they will be unable to do so in the short term. Only when capital investments have been made and additional control capacity has been installed (i.e., firms operate on long-run control cost curves), will such trades be feasible.

Government authorities may have to intervene both to address the problem of inadequate future supply of permits and to alleviate the consequence of permit hoarding or market manipulative behaviour. A subsidization program to encourage the banking of permits may be introduced to offset the uncertainty regarding future permit values. Alternatively, an option may be for authorities to withhold a certain proportion of the permits with the option of selling these in the future to sources that cannot obtain permits on the market. This would also provide direct access to permits that can be retired if standards need to be tightened over time. The role of authorities as a market participant should be well defined and known to all the players from the initiation of the program; otherwise it may create an additional source of uncertainty and actually inhibit the establishment of an active permit market.

2.3 Comparing Permit Trading to Other Policy Options

It must be clearly understood that any policy designed to internalize external costs requires intervention in current operating practices. Market-based policy tools are in line with the current trends toward deregulation and reduced government intervention in the economy. By assigning ownership to the right to pollute, emission sources are given the incentive to utilize efficient input combinations in order to maximize profits, while at the same time complying with the required emission constraints. Using market-incentive tools is not equivalent to non-intervention. A market incentive policy utilizes the competitive market economy to achieve the least-cost allocation of resources to pollution abatement, while correcting for the external social costs caused by pollution.

There are a number of assumptions that must be fulfilled for the least-cost criteria to be realized in an actual implementation. The practicality of these conditions is further explored in Chapter 3, but first the characteristics of and conditions for a tradeable permit system are placed in context through a comparison with alternative policies.

2.3.1 Approaches to Environmental Policy

An overview of environmental policies is presented in Table 2.1. These various approaches are obviously not mutually exclusive. Most environmental policies represent a hybrid of options. Past Canadian policies have contained various forms of moral suasion and substantial elements of government investment, as well as the prevalent command and control option.

This comparison of policy approaches is by no means a complete review of all the options available. It contrasts the traditional direct control approach relative to the market-incentive policies, and compares the different types of market incentive tools. Of particular interest among the market-based policies is a comparison between the emission tax and tradeable permit options. There are other tax options that are not directly emission taxes, and therefore not mentioned in Table 2.1, but that would have an impact on emissions. Specifically, product and resource taxes are commonly discussed as environmental policy tools, and these kinds of taxes are included in this review. For example, a tax on gasoline, on fossil fuels relative to carbon content, or on manufacturing products represents a tax policy alternative to a pure emission tax.

It is important in reviewing these instruments to keep in mind that all the policy tools entail some form of interference with, or regulation of, the market solution. The term market incentive policy does not imply that the market is left to regulate itself. However, the policies can be compared in terms of their administrative burden and the degree of interference required.

While a formal evaluation and ranking of policy options is not attempted in this study, the following points are considered when comparing the attributes of these options:

- effectiveness;
- cost efficiency;
- equity, or distributional effects;
- administrative feasibility such as ease of monitoring and enforcing;
- political acceptability; and

TABLE 2.1

POLICY INSTRUMENTS

Moral Suasion (publicity, social pressure, etc.)

Direct Controls

- Regulations limiting the permissible levels of emissions
- Specification of mandatory processes or equipment

Market Processes

- Taxation of environmental damage
  - Tax rates based on evaluation of social damage
  - Tax rates designed to achieve preset standards of environmental quality
- Subsidies
  - Specified payments per unit of reduction of waste emissions
  - Subsidies to defray costs of damage-control equipment
- Issue of limited quantities of pollution "licenses"
  - Sale of licenses to the highest bidders
  - Free distribution of licenses with legalized resale
- Refundable deposits against environmental damage
- Allocation of property rights to give individuals a proprietary interest in improved environmental quality

Government Investment

- Damage prevention facilities (e.g., municipal treatment plants)
- Regenerative activities (e.g., reforestation, slum clearance)
- Dissemination of information (e.g., pollution-control techniques, opportunities for profitable recycling)
- Research
- Education
  - Of the general public
  - Of professional specialists (ecologists, urban planners, etc.)

SOURCE: William Baumol and Wallace Oates, *Economics, Environmental Policy and the Quality of Life* (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1979), p. 218.

- flexibility to accommodate economic and technological changes.

2.3.2 Market Incentives Versus Direct Control

Direct control usually requires that the government sets and enforces emission standards for processes or equipment. As Table 2.1 indicates, it can alternatively consist of authorities mandating specific equipment for certain processes. This option is quite often seen in association with a government subsidy program to ease the transition for industry in adapting to higher environmental standards. Even when authorities stop short of mandating the use of certain equipment and simply enforce performance standards on processes, these standards are usually set with reference to a certain equipment choice. The effect is then in reality the same as enforcing a specific technology solution.

The costs involved in such a policy are obvious and will be discussed in more detail below, but it should be noted at the outset that this direct control option is also associated with two unique benefits. For any of the market-incentive policies, it is necessary to monitor actual emissions to ensure compliance. In selecting and enforcing a "best technology" option, there may be no further need for continued monitoring of the source once the equipment is in place. To the extent that this policy can be perfectly implemented, the direct control option may also entail the benefit of no further policy adjustment costs, since the target will be met without any uncertainty.

A system enforcing "best available technologies" (BAT) also implies that the state of production technologies dictates total emissions, as opposed to the ideal approach which entails determining appropriate emission standards prior to selecting a policy. The BAT policy also represents a further disincentive to technological change, since it implies that development of a new technology leads to immediate implementation regardless of the costs. To avoid this, it is possible to qualify the policy to only enforce adoption of commercial technologies. In this case the definition of commerciality becomes a contentious issue given the wide variety of operating conditions among existing plants in any industry.

The costs of letting government authorities pick "winners" among available technologies must be recognized. Not only is it difficult and costly for someone not directly involved in a specific production process to decide on the best technological adaptation to meet

emission standards, but also the optimal technology choice will vary significantly from plant to plant even for the same process. Considering the number of processes responsible for CO_2 emissions, the information burden for optimal technology choices becomes very large.

The same is true for setting and enforcing emission standards on processes and equipment. Ideally, individual standards should be set such that those sources whose emission control costs are relatively low bear the major responsibility for reducing emissions, and those sources with relatively high emission control costs are allowed a more liberal standard. In this way the control solution can be achieved at minimum cost. **Clearly, the fundamental problem with the traditional approach is that control authorities find it difficult to achieve a cost-effective solution, since they do not generally have access to accurate information on variations in costs of compliance among emission sources.** In order to ensure a cost-effective solution, the control authority requires information on all technical means of emission control, as well as the marginal costs of control associated with each of these technologies, for each source of emissions.

Market-based options offer a potential for control cost savings. However, it is still necessary to analyse these savings to determine whether they are sufficient to offset the costs involved in implementing and monitoring, for example, a tradeable permit system. Since actual comparisons cannot be carried out, simulation studies have proven useful for this kind of cost comparison. Generally, it has been estimated that the potential cost savings of a least-cost, market-based solution over the command and control approach are substantial. Estimates from such simulation studies indicate a 72 percent cost savings with a market solution to controlling airport noise[6] and 68 percent savings for a hydrocarbon emission trading system.[7] An emission trading system for CFCs was estimated to entail 96 percent cost savings compared to costs incurred by a direct control approach.[8]

Note that these simulations were based on the assumption that a direct control policy will specify that every pollution source must meet the same, uniform standard of emissions, proportional to the total emission reduction required. In reality, even if full information on marginal costs is not available to authorities, there is a general understanding of which sectors represent high and low cost sources of pollution abatement respectively, and standards are not likely to be uniformly applied across all processes or sectors in the economy. This

will improve the cost-effectiveness of a direct control policy. The simulation studies also assume full compliance, and costs associated with administration, monitoring or enforcement are not included. Even given these qualifications, the theoretical cost-saving potentials are impressive and remain the principal argument for exploring the emissions trading policy option further.

It is argued by some that a standard enforcing system without any trade will achieve a higher level of control than if permit trading is introduced. This is based on the assumption that a large number of sources are already performing better than the emission standard. In a trading system, these low polluters would be able to sell permits equivalent to their exceedence of the standard. Thus, on average all sources would just meet the set standard, while minimizing the total cost of abatement. In a direct control system, all sources would have to meet the standard, and those performing better than the standard would simply continue to do so. This creates average emissions below a market-incentive policy solution. If the net benefit of less pollution outweighs the cost savings of permit trading, the direct control option becomes the least-cost policy.[9]

While this is an interesting argument, it is a contentious issue to evaluate the benefits of pollution control beyond the set standard. Since theoretically the level of control is determined by equating the social marginal benefit of control to the social marginal cost of control, the socially optimal level of pollution is determined prior to the implementation of any policy. Theoretically, market-based policies simply represent the least-cost method to achieve a set pollution control target. If benefits of additional control are to be calculated, then the full costs of higher standards, including human costs of lost employment and multiplier economic effects, should also be included. The result is also dependent on the existence of a large number of emission sources that perform better than the standard. For CO_2 emissions this is not likely to be the case, considering the strictness of the goal and the relative scarcity of control technology options. However, the argument underlines the importance of carefully defining the benchmark for standards, since a too liberal standard in the case of market incentives could actually serve to degrade the environment further, while constituting a wealth transfer to polluting industries.

A final consideration must be made of the claim that the public has a basic right to a clean environment. From this perspective,

the concept of selling pollution permits is tantamount to selling a "right to pollute", which is morally reprehensible. Taken to the extreme, the consequence of this argument would be to shut down all production activity in our economy and completely change the lifestyle to which developed societies are now accustomed. While this may be philosophically appealing to some, it is not a politically or socially acceptable goal. The counter-argument to an objection to selling "rights to pollute" is that at least it is better to make the polluter pay a price for harmful emissions than to continue to allow pollution of the atmosphere at no charge.

The issue at stake here is the definition and granting of property rights to environmental resources. It is a misinterpretation of the traditional direct control system to assume that the public in this case maintains all rights related to these resources. Direct control policies, such as standards, provide firms with the "right to pollute" up to a prescribed limit, while the public retains rights to environmental purity above this limit. In this regulatory framework, firms cannot **acquire** the rights to pollute; they are freely granted up to the limit imposed. Alternatively, a fee or permit system recognizes that all property rights to resources are public, but either allocates or allows the firms to purchase the right to use environmental resources for waste disposal. The key point is that a permit system also directly limits the quantity of emission rights, by issuing a limited number of permits.[10] The only difference is that with permits, rights are transferrable; with command and control, rights are installation specific.

Market incentive policies are based on the assumption of an efficiently functioning market economy. Perhaps the most forceful argument against market incentive policies is the claim that the industrial structure of our society does not conform with the "competitive market" described in economic theory. To the extent that individual firms can exert market power on their product markets, or even influence the political decision making process, the competitive functioning of a permit market and even the setting of emission standards may be jeopardized. The consequences of noncompetitive behaviour were discussed in the theory section above.

2.3.3 Emission Taxes Versus Permit Trading

In a permit trading system, once society has decided on the acceptable quantity of emissions, a market price for permits is established through trades in the market in accordance with the marginal

costs of emission control by sources. The market price reflects the difficulty, in terms of costs incurred, which emitters experience in achieving the emission standards. The quantity of emissions allowed determines the number of permits issued on the market. Alternatively, with perfect information, the size of an optional emission tax (or effluent fee) could, theoretically, be set to achieve the same reduction in quantities of emissions. The tax then penalizes the polluter in such a way that the full social costs of production are internalized, adjusting the polluting emissions to a quantity deemed "optimal" by society.

In theory, then, this is a choice between two market-incentive policies that achieve the same result. In both cases an optimal solution from society's point of view is found by equating the marginal social benefit to the marginal cost of controlling an emission. In a competitive market the price of a permit will be bid up to a point exactly equal to the optimal tax, given that the quantity of permits is set in accordance with the socially optimal quantity of emissions. Alternatively, the tax will be set so that a socially optimal quantity of emissions is controlled. In other words, the polluter should be indifferent between paying the price of permits or paying the tax rate per unit of emissions.

2.3.3.1 Policy Effectiveness

The important difference between these two policies lies in the variable that is chosen as a policy tool. In the case of permits, the control variable is the quantity of emissions permitted. In the case of an emission tax, the price variable is the policy tool. Since the theoretical result is brought about using different tools, it is to be expected that the ease of implementation and practical success of the two policies may not be the same. In particular, in the real world where uncertainty plays a major role, these two policies may lead to very different results.

In the case where an under- (or over-) achievement of the emission reduction target leads to significant social costs, a policy tool that directly determines the quantity of emissions is preferable. Alternatively, if there is considerable uncertainty with respect to the costs involved in emission control, it will be difficult to meet the emission quantity target using a tax policy. In both these cases a permit system has the advantage of fixing the quantity variable, thereby eliminating the uncertainty related to choosing the correct tax rate to achieve a certain level of emission reductions.

On the other hand, if it is known that the costs of emission abatement are rising rapidly with higher standards of emission control, the tax policy may have an advantage. In this case the quantity variations in total emissions induced by different tax rates would not be very great but the costs associated with over-regulating the quantity of emissions would be substantial. A conclusion that follows from the theoretical model of policy options is, therefore, that the steeper the marginal cost of abatement function, the greater is the cost penalty associated with a sub-optimal quantity target for a permit policy, and the smaller is the deviation from the optimal quantity of emissions by a miscalculated tax policy. This appears to be a case where the tax option has an advantage over tradeable permits.[11]

In reality, as discussed in Section 2.2, the costs of abatement are likely to be represented by step-functions. At certain intervals it will be necessary to introduce completely new technologies to tighten emission standards further, resulting in large cost increases for relatively small reductions in emissions. Between these jumps in the function, less costly modifications to the current technologies are possible and are reflected in relatively flat segments in the cost curve.

Likewise, the social benefits-of-control schedule is likely to exhibit step-function behaviour. This is due to so-called threshold effects in the environmental damage caused by pollution. If current concentrations of a pollutant are close to a threshold, a marginal increase in emissions can cause sudden, large increases in environmental damage. In this case, a permit policy will have the advantage of fixing the quantity of emissions directly, ensuring that the threshold value is not exceeded.

A general consideration with respect to the effectiveness of a permit system is that permits are not realistically an option for all emission sources. The numerous smaller sources in the residential sector, or the small and mobile transportation sources, would be difficult if not impossible to control within a permit system. In this regard, a tax policy may have the advantage of better potential coverage and hence higher effectiveness.

This review of policy options is not intended to select the "best" option, but simply to explore their differences in order to enhance the understanding of where and how a policy is most applicable. An actual emission policy would consist of a number of options targeted at different sectors in accordance with source and policy characteristics.

2.3.3.2 Flexibility

A very important consideration in designing an emission policy is to incorporate sufficient flexibility to accommodate economic changes and to allow for tightening standards over time. If a nominal tax is left unchanged, inflation will gradually erode the effect of that tax. Most taxes are expressed in percentage terms to avoid the need to continually increase a nominal tax. For an emission tax a percentage expression would not be practical. To tighten emission standards over time, the tax would have to increase at a higher rate than inflation. Such tax increases would be both difficult to calculate and politically insupportable.

With a permit system it is necessary to withdraw a certain number of permits in order to reduce emissions further. This can be accommodated either by having an expiry date on all permits coupled with regular re-issue of new permits, or by the government purchasing and retiring a certain number of permits on the market at given intervals. The problems of adjusting a tax rate over time must be weighed against the administrative burden of re-issuing or purchasing permits.

A similar complication is introduced with growth in emission sources over time. Again, to achieve a given standard it would be necessary to continually increase the tax rate as the number of emission sources increase, while with a permit system the price of a fixed quantity of permits would be automatically bid up. Tradeable permits in this case have the advantages of avoiding the risk of a deteriorating standard and of circumventing the problems involved in increasing tax rates over time. However, in a dynamic market the "optimal" level of emissions becomes a moving target, and a permit system does not eliminate the costs and problems involved in policy adjustment.

The complexities introduced by spatial and time variations in acceptable emissions are more difficult to accommodate with market incentive policies. With a tax policy it would be necessary to apply differential rates depending on location. Provided that the borders between different taxation areas can be clearly defined, this is not an impossible task, but the problem of setting the correct rate to achieve a certain emission standard is multiplied. Furthermore, for some types of emissions, especially those contributing to ozone formation, the time of year or even the time of day matters to local air quality. To address these variations with a tax policy would require a form of peak-load tax system with differential rates depending on the total allowable volumes of emissions at various times. The practicality of such a

complex tax system hinges on the ability to not only determine the correct tax rate to achieve a certain quantity of emission control, but to be able to continually and accurately monitor variations in emissions and determine the appropriate tax rate response. Differentiation in tax rates based on location may also be politically difficult to accomplish.

With a permit system, local air quality problems can be addressed by designing different classes of permits according to location of the emission source. The information requirements become essentially the same as for the tax policy. Each permit zone would have to meet certain conditions to ensure a competitive market, with possibilities for trade within each class of permits. Alternatively, trade between different classes of permits could be accommodated if relative values of the permits are specified. For example, a class A permit pertaining to an urban zone may be worth two class B, rural zone permits. Accommodating time variations in emissions in a permit trading system would likewise require different classes of permits for peak emission times than for low pollution hours, days or seasons. While this is theoretically conceivable, it would be a very difficult, if not impossible, system to establish and enforce.

Further complications to implementing a time and space sensitive emission policy arise, in that such policies have important implications for local planning and hence for development, land use and income generation in an area. Implemented on the federal level, it is difficult to fairly assess all the local ramifications of a policy. If implemented on a local level, it is difficult to coordinate and maintain the desired national emission target. Such problems related to choosing the most effective and politically acceptable level of government for design and implementation of a policy are also entangled in jurisdictional issues.

In conclusion, it may be easier to take account of spatial variations in emissions in a permit trading system than with differential taxes. However, the existence of competitive market conditions for the permits must be ensured. With respect to time variations, it is difficult to design a responsive and flexible market incentive policy. This appears to call for a combination of policy tools with a basic permit system combined with direct controls to limit emissions at certain times or in certain areas.

The design of an appropriate permit system to control greenhouse gas emissions in Canada may be a less complex task than

it would be for other emission problems. Because we are concerned primarily with the total level of emissions released from Canadian sources, and not with the ambient concentration levels at specific points across the country or at certain times, the spatial and time complexities of the control problem can be avoided. In order to avoid the consequences of global warming, only aggregate levels of emissions need be considered in the control problem. It is not necessary to control the distribution of emissions from different major sources of discharge across the country. Furthermore, changes in the distribution of total emissions resulting from trading of permits do not affect the outcome of aggregate emissions.

2.3.3.3 Equity and Political Acceptability

The political resistance to the creation of new taxes can be substantial. If an auction is chosen over a free distribution system for permits, in theory the revenue created by auctioning permits would be identical to the tax revenue of an optimal emission tax. However, any new tax policy carries the stigma of being a "revenue grab" by the government, and taxes would still represent a less politically acceptable option. The experience in OECD countries confirms that most existing emission fees are levied for financial reasons and that these taxes do not greatly affect environmental outcomes.[12]

In contrast, a permit system, dealing directly with quantities of emissions, may be perceived as being primarily an emission control policy. As seen in Section 2.2.3, the government revenue generated by permits depends on the initial distribution policy. If the permits are initially freely distributed, obviously no government revenue is raised. The potential for very large transfer payments between industry and government is present for any economic incentive program. In addition, the regional distributional effects, inter- and intra-industry transfer payments and international equity effects must be considered.

A tax policy may be at a disadvantage relative to a permit policy with respect to flexibility and accommodating growth without frequent and costly intervention. However, adjustments to a permit system may prove politically difficult for different reasons. If permits are interpreted to actually represent property rights to an environmental resource, it may be legally and politically difficult to revoke or withdraw a permit from the market. Although a permit system may require less frequent adjustments than a tax policy, given the direct

quantity control and the economic flexibility of this option, when standards must be changed it could be a difficult process. This must be considered when designing a permit system, in particular, in specifying the duration and re-issue procedures.

2.3.4 A Product or Resource Tax Versus an Emission Tax

The main obstacle to any market incentive policy lies in our ability to measure and monitor emissions. For a tax policy, the exact emission quantity response to a given tax rate introduces an additional degree of uncertainty. A commonly suggested alternative is to tax the fossil fuels themselves rather than the emissions resulting from the combustion process. It appears from public debate around this issue that an energy tax is perceived as being close to identical to an emission tax. This misconception must be clarified.

While taxing fossil fuels would avoid the problem of monitoring emissions, it would also remove the policy impact even further from the actual polluting activity. This introduces another element of uncertainty as to the actual effect of a tax on quantities of emissions. The sensitivity of a production process to a change in the price of the fuels, and the resulting change in consumption of fuels and thereby in emissions, is difficult to predict.

Furthermore, it is not evident that a fuel tax is in accordance with the least cost-of-compliance solution. The choice of a fuel tax is based on the assumption that the best and cheapest ways to reduce emissions are to decrease energy use or switch to a fuel with lower carbon content. This is the reason fuel taxes have been discussed in relation to controlling CO_2 emissions. While this may be a valid assumption for certain emissions and for some emission sources, it cannot be assumed to be universally true. **By implementing a fuel tax, a government, in effect, chooses specific solutions to emission control, namely conservation or fuel switching. Market incentive policies are designed specifically to avoid the regulation of a single option for emissions reduction.**

The fuel tax rates would have to be set proportionately to the pollution potential for all types of fossil fuels. For example, low and high sulphur coal would be subject to different SO_2 taxes, and natural gas would receive a lower carbon tax than residual fuel oil. But determining a fair proportionality formula is not as

straightforward as analysing, say, the relative sulphur content of a fuel, since final emissions depend on the combustion technology employed. Coal sold for use in a traditional coal-fired boiler should obviously be penalized more heavily than coal going to a process with scrubbers, since the level of emissions per unit of output energy without scrubbers will be significantly higher.

An alternative to a primary fuel tax would be a manufacturing product tax, again somehow set proportionately to the amounts of emissions resulting from the production of each product. In terms of the resulting economic adjustments, a product and a resource tax would have identical impacts on both the product and input markets, providing both taxes were set to effect the same reduction in energy consumption. However, the difficulties of determining and implementing appropriate, proportional tax rates for all manufactured products are prohibitive. Product taxation would not encourage process or input substitution by the producer, or provide an incentive for development of new, cleaner technologies.

Another variation on an energy tax that has been suggested is an end-user, value-added tax on energy consumption. While this tax structure leads to a more direct link with costs of production in the polluting industry, it further obscures the link to emissions. In fact, a value-added retail energy tax could have the perverse effect of favouring cheaper and dirtier fuels over clean-burning, more expensive alternatives. Theoretically, at least, such a substitution effect could outweigh reduced emissions from energy conservation measures, leading to deteriorating emission standards. Environmentally clean energy forms, such as electricity generated from solar, hydro or wind power, would be penalized equally with thermally generated electricity, when sold at the same price. The only advantage of such a tax is that it eliminates the need to continually adjust the tax rate for inflation.

Any consumption tax is regressive in incidence, but the exact distributional effects can only be ascertained by case-specific studies. In general, the more price-sensitive the demand for a product or input, the larger is the burden of the tax on the producers of that product or input, relative to the consumer. For a product or resource tax policy to be effective, demand would have to be fairly price sensitive to effect the necessary quantity reductions. This implies that

producers of the resource, or of the product, pay a proportionally larger share of the tax, since prices cannot be increased to compensate for the tax.

2.4 Conclusions

The theoretical assessment of a permit trading system has made it possible to outline a series of specific conditions necessary for establishing a successful trading program.

- To avoid strategic behaviour and manipulation of the allocation of permits or the permit price, there must be a sufficiently large number of emitters in a trading program to establish a competitive market.
- The more diverse the costs of compliance, the larger are the potential benefits from trade.
- The fewer the restrictions placed on transferability of permits, the closer the market will come to achieving the lowest cost of compliance.
- It is much easier to establish a trading program for a uniformly mixed pollutant than for emissions that cause damage to specific areas or during specific time periods.
- Auctioning permits may lead to cost increases for the polluters that negate the cost savings of a permit system relative to a uniform regulatory approach.
- Market manipulative behaviour in a non-competitive permit market can be eliminated by implementing an incentive compatible auction system. If the costs of purchasing permits are deemed too excessive, an auction-refund system can be designed to allow for initial distribution of permits in accordance with their individual costs of compliance.
- A free allocation of permits that provides an incentive to trade represents a wealth transfer policy. As such, any allocation formula must be subject to economic impact analysis and accompanied by a policy statement.

Since these conclusions are based on a theoretical assessment of permit trading, this chapter has not dealt with the more practical problems such as enforcement and monitoring, and establishing appropriate benchmarks as a basis for permit allocation.

The major problems related to a permit trading system are predicted to be in the areas of monitoring and enforcement, and in the distributional effects of transfer payments between emitting sources and governments, and among industry sources. In addition, if the sources do not constitute a competitive permit market, distributing permits to existing sources can create serious barriers to entry for the industries concerned. The theory also assumes that a single policy can be applied to all sources of emissions, which in practice is not feasible.

A complete evaluation of policy approaches would require detailed information on current and future technology options and related costs and emissions by source. This information would enable comparisons of costs of implementation by policy tool for specific environmental goals. This brief overview has served to highlight the different characteristics of some of the policy tools and, thereby, provide some guidelines to the conditions under which a tradeable permit system would be likely to succeed.

- While emission taxes and permits will in theory achieve the same goal of cost minimization, the uncertainty related to choosing the right tax rate for achieving a certain quantity of emission reductions gives permits an advantage as a practical policy tool when the environmental goal is expressed as a quantity target.

- If current concentrations of emissions are close to a threshold for environmental damage, it is particularly important to achieve the desired quantity of emissions target.

- On the other hand, an emissions tax may be preferred if the control costs are rapidly escalating or are unknown, since this would directly control the costs of compliance.

- Given that a permit system could not be universally applied, a tax policy may have greater overall effectiveness. And although adjustments to a tax rate would need to be more frequent and would be politically unpopular, the withdrawal of permits before the set expiry date may prove difficult, leaving authorities less control to adjust the permit policy once implemented.

- A market incentive policy is generally much easier to implement for a uniformly mixed pollutant such as CO_2 than for emissions related to local air quality problems

- Permits may also have an advantage over taxes in political acceptability, in flexibility to accommodate economic growth and inflation, and in providing an incentive for technological advances.

- Alternative tax policies, such as energy excise taxes, manufacturing product taxes or carbon taxes on fuels, are not likely to achieve the socially optimal, least-cost solution, but they have the advantage of ease of implementation and monitoring compared to an emission policy.

Practical aspects of policy implementation in relation to the specific CO_2 case study are discussed in Chapter 4. Before turning to this potential application of a permit trading system, it is beneficial to review experience with permit trading in actual implementations. From the review of practical experience with permits in Chapter 3, further conditions and recommendations for establishing a successful trading program are generated.

Footnotes

[1]William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy*, 2d ed. (New York, New York: Cambridge University Press, 1988).

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[11]William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy*, pp. 57-78.

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Chapter 3

EXPERIENCE WITH MARKETABLE PERMIT SYSTEMS

While the theoretical literature on the subject of marketable emission permits continues to accumulate, the actual implementation of such programs remains limited. In spite of the small number of actual applications, there is much to be learned from these practical experiences with permit markets. Specifically, problems associated with high transaction costs, insufficient competition, restrictions on trade, and uncertainties regarding emission property rights have limited the ability of market systems to achieve cost effective allocations of control. The characteristics and the relative success of five market programs in the United States are examined below. Three of these programs are past applications; one is an on-going initiative; and the last case is a new initiative yet to be implemented.

3.1 Fox River Transferable Discharge Permit Market

The U.S. pulp and paper industry is closer to an oligopolistic than a competitive market structure and the waste water treatment plants are subject to public utility regulation. Neither industry, therefore, fulfills the competitive market criteria for successful trading of permits. Furthermore, in order to mitigate the pollution concentration levels in two peak areas of the river, the market participants were divided into two groups according to location. Since trading was allowed only between the six or seven firms in each group, the market for trading permits remained quite limited.

Restrictions imposed on all trades confined the market even further to those firms wishing to expand their production, to new industry and to those firms which could not meet control requirements. For example, it was required that firms justify the need for permits based on considerations other than cost effectiveness. Those trades which served only to reduce the cost of compliance to achieve the program's targets were not allowed.

The trade restrictions also created uncertainty around the future value and the long-term ownership of a traded emission permit.

Any permit tranafer was required to last for at least one year, but a permit buyer had to forgo all rights to renew the permit past its expiry date.

Consequently, the market created was too limited and restricted to facilitate adequate trading, and expectations for cost reductions were not met. Over a period of six years only one trade occurred. The initial expectation of control cost savings of approximately $7 million was not realized.[1]

3.2 Lead Trading

In contrast, the lead trading program initiated in the United States has been quite successful. The program provided gasoline refiners greater flexibility in reducing the levels of lead in gasoline through a system of banking and trading of lead credits. External trading was initiated in 1982 and limited banking was permitted in 1985. The program had a fixed life and was terminated in 1987. All sources, both old and new, were allowed to participate and limitations on the trading of credits were minimal. Credits were initially allocated freely in accordance with average lead content in current production. Consequently, a freely functioning competitive market was created, resulting in levels of trading activity great enough to conclude that substantial costs savings were realized.

Over one half of U.S. refineries participated in the trading of 15 percent of total lead rights. Although data on actual cost savings attributed to the program was not collected, the EPA's initial estimate of $228 million in potential savings was likely exceeded, since levels of trading and banking activity were somewhat greater than initial expectations.[2]

The success of the program was largely attributed to the fact that an unrestricted, competitive market for permits was created among refiners. In addition, credits for lead could be readily defined, and levels of lead in the gasoline produced were easily monitored using existing equipment. Potential problems associated with resolving uncertainties concerning credit entitlements were therefore eliminated.[3] Allocation of permits based on current lead concentrations provided a non-controversial initial distribution, and the known duration of the program eliminated any uncertainty regarding future policy revisions. Refineries are also used to dealing extensively with each other in trading both feedstock and process flows as economic and operating conditions fluctuate. Finally, the program was implemented

to achieve a well-defined environmental goal, the elimination of leaded gasoline, for which there was general public and political support.

3.3 EPA's Emission Reduction Credit System

In an effort to move toward increasing reliance on market incentives to achieve air quality targets, the Environmental Protection Agency (EPA) in the United States implemented a system for emissions trading for sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. The program was implemented in 1974, but the specific trading policies were developed and changed over time.[4] The stated objective of using a market approach for air quality protection was to encourage flexibility in the use of control strategies employed by emitting industrial sources, while maintaining air quality standards as well as specific emission standards imposed by the EPA. In other words, this system is a hybrid of marketable permits and direct control measures.

Under the program, any source which controls emissions beyond the level required under the regulatory standards established by the EPA may apply for certified emission credits which may subsequently be used in the netting, bubble, offset, or banking programs. These programs regulate how and when credits may be created, used and traded. The specific conditions are reviewed in detail below.

The system clearly falls short of establishing an ideal, freely functioning market in emission licenses, but it has been relatively successful in achieving control cost reductions. Cost savings have been estimated in the hundreds of millions of dollars. The program has also succeeded in maintaining existing air quality levels.[5] Further examination of characteristics of the program and specific areas of success and failure provide useful insights into the necessary conditions for the success of a permit trading policy in practice.

3.3.1 The Netting Program

The netting program introduced in 1974 allows firms to create new sources of emissions in a plant without being subject to stringent emissions control regulations. The program requires that the additional emissions associated with plant modifications be offset by reductions from other sources within the plant, such that the net increase in emissions is less than the emissions level which the state sets for major pollution sources. Because the impact of any positive net increase in emissions which is below the major source level is not

expected to significantly harm air quality, the stringent control requirements associated with major source permits can be avoided and additional emissions subject only to the less stringent requirements assigned to minor sources.

The netting program has clearly been the most successful of all emission trading activities, in spite of the fact that it accommodates only internal trades. Though little information is available on actual transactions, reasonable estimates of the extent of its usage from 1974 to 1984 indicate that 5,000 to 12,000 sources participated in the netting program. Based on estimated average cost savings ranging from $100,000 to $1,000,000 for each transaction, the total value of cost savings attributed to the program is estimated to be in the order of $500 million to $12 billion.[6]

Despite this large cost saving, the potential for adverse air quality impacts cannot be ignored. The basic premise of the program is that each netting transaction will increase emissions by an amount less than the major source level and, accordingly, only insignificant impacts on air quality will be experienced. Yet, in the case where many sources in a single area use netting, the concern for air quality impacts may arise. State control authorities have not to date imposed additional emissions control constraints on the new emission sources resulting from netting transactions. On this basis, it can be assumed that the deterioration of air quality as a result of the policy has not been significant.

While the program has been acclaimed for its achievements in reducing control costs, it should be pointed out that the incentives provided under the program do not encourage the development of a market in emission licenses since only internal trades are recognized. Furthermore, the program may actually provide a disincentive for firms to participate in the market since there is a direct incentive to hold on to emission credits for future netting opportunities.

3.3.2 The Bubble Policy

The bubble program initiated by the EPA in 1979 allows for existing emitters within a designated area, or bubble, to adjust their control strategies so as to minimize costs, while at the same time maintaining a level of aggregate emissions from all sources within the bubble which does not exceed the sum of their individual emission requirements. In other words, only the aggregate amount of pollution leaving the bubble is regulated. In the case where marginal control

costs vary across the different sources contained within the bubble, incentives will exist for emitters to adjust their level of control. Those sources with relatively high marginal costs will be encouraged to decrease control and exceed the standards imposed on them by the control authority if they are able to sufficiently reduce emissions from sources with relatively low marginal control costs. In this way, a cost efficient allocation of control within the bubble can be achieved, while at the same time the aggregate emissions standard is maintained and air quality is not adversely affected. To the extent that marginal control costs vary significantly across all sources, the potential cost savings under the policy may be substantial.

In terms of actual performance, the EPA has estimated that cost savings in the order of $300 million have been realized from the forty-two bubbles it has approved to the year 1985.[7] However, of these forty-two, only two approved bubbles have involved trades between different companies, suggesting that the cost saving potential which exists for industry has hardly been realized. Further examination of reported cost savings indicates that unless the benefits of using the bubble approach to control allocation are very large, firms will not be encouraged to incur the high transaction costs associated with the planning and preparing of bubble applications.

In addition to those bubbles approved by the EPA, eighty-nine bubbles have been approved to the end of 1984 under state generic rules. The EPA has estimated that the cost savings involved with each state approved bubble is approximately $3 million. Hahn and Hester (1987) suggest that a value of $1.5 million is more appropriate. The reason for the significant increase in state approved bubbles relative to federally approved bubbles reflects the fact that bubbles approved under the EPA require additional processing, which is both time consuming and costly to the firms involved. Again, the indication is that high transaction costs can deter firms from participating in emission trading.

Generally, it would appear that the bubble policy has been successful in providing significant cost savings to industrial sources of pollution by introducing greater flexibility in the control options available to them. These savings have been realized without any significant degradation to the environment. On the other hand, it appears that potential benefits under the program have not been achieved. The fact that only two external trades have occurred indicates that an active market in emissions trading has not developed.

3.3.3 The Offset Policy

Under the authority of the Clean Air Act, the EPA has been assigned responsibility for setting maximum allowable concentration levels for selected pollutants, while each state has been assigned the task of implementing these standards. In states with non-attainment areas (i.e., regions which have been unable to achieve these air quality targets), the conflict between pollution control and economic expansion has been particularly difficult to resolve. State implementation plans to achieve air quality targets in non-attainment regions would have required curtailment of all economic expansion in these areas, if improved emissions standards from existing sources had not been achieved.

The offset program was specifically established to allow for new emission sources to locate in non-attainment regions. The basic premise of the policy is that new sources will be allowed to locate in non-attainment areas if they are able to offset their emissions with decreases in emissions from existing sources. In other words, by purchasing sufficient emissions reduction credits from existing sources, new and expanded industry may offset increases in emissions which would have occurred from incremental production.

It is difficult to estimate actual benefits realized to date by the program due to a lack of data. Only a relatively small number of trades have occurred and typically these have been limited to internal trades (i.e., trades within firms). It is important to examine why potential external trades have not occurred and why an active market in offset trading has not yet been established.

The problem can partly be attributed to the high costs associated with identifying potential offset sellers. Buyers may incur costs of thousands of dollars in the search for potential offset opportunities. Such costs may substantially reduce the incentives for trade unless cost savings are deemed to be large. In other words, while it is unlikely that non-attainment areas characterized by high economic growth would experience difficulty in attracting willing buyers for emissions credits, the high costs of identifying potential sellers may be prohibitive. The permits in essence come to represent a substantial barrier to entry.

The offset program also illustrates the problems inherent in introducing a market in emission permits within a regulatory framework. This limits the potential for control cost reductions through

trade. In the case of offset trading, the policy is limited by the requirement that all new sources maintain stringent levels of control. The trading opportunities between existing and new sources of emissions are restricted, since the extent to which existing industry may offset additional emissions associated with new sources is limited.

This restriction on trade may also have the adverse effect of actually delaying improvements in environmental quality. If existing industry operates under less stringent control requirements, and therefore incurs relatively low marginal costs of controlling additional emissions, the retirement of high-emission sources may actually be postponed, negatively affecting air quality. At any rate, it is expected that the cost reduction potential realized through the restricted trading options of the offset policy will be less than optimal.[8]

Concern has been expressed that offset trades may actually be responsible for degrading air quality. This concern is more appropriately directed at the inadequacy of state regulators to calculate baselines for emission permits, rather than at the design of the offset program. The problem occurs when allowable emission rates assigned to sources exceed actual rates of emissions, and firms subsequently receive credits for surplus reductions when in fact no actual reductions have occurred. These "paper credits" create the potential for industrial sources to increase their level of emissions, which in turn adversely affects air quality. While this concern is not inherent in the offset policy itself, it does point out the need for accurate inventories of actual emissions so that baselines may be calculated that serve to maintain and improve air quality.

3.3.4 Banking

The banking program, introduced by the EPA in 1979, allows firms to save emissions allowances either for future use or for future sale to other firms. The premise of the program is to reduce the uncertainty associated with the ability of a firm to use emissions reductions in future transactions. In actual practice, however, levels of banking activity have been less than anticipated.

Approximately thirteen regions of the country had adopted banking rules by 1986. Of these, only one program--established in Louisville, Kentucky--could be considered active. The success of the Louisville program is attributed to the fact that few restrictions have been placed on the use of banked credits. Lack of activity in the other programs mainly reflects restrictions on the use of banked emission

credits to offset internal sources only. More accurately, the inactivity may be explained by the uncertainty associated with the property rights for banked emission credits.

The possibility that banked emissions credits may be discounted or eliminated by control authorities has further discouraged participation in the program. For example, if new emission standards are imposed on an emitting source which has banked credits held by the state authority, these emission credits may be discounted to reflect the new standards. Alternatively, if state air quality targets have not been achieved, control authorities may confiscate banked emission credits in order to encourage compliance. The fact that in some cases the property rights associated with banked credits are recognized only for a period of time has also created uncertainty for potential participants.

In view of the fact that the objective of market systems in emissions permits is to address the problem of the lack of property rights associated with environmental amenities, failure to define and guarantee property rights of permits will undermine the policy's success in promoting cost savings and air quality improvements.

3.4 U.S. CFC Permit Trading

In order to meet its commitment under the 1987 Montreal Protocol to control ozone-depleting chemicals, the EPA has recently instituted fully tradeable CFC permits. These permits have been allocated freely on the basis of historical production or imports, and will remain valid for one year with fewer permits issued every year to gradually tighten the standards. Trade in permits is unrestricted with no new ban or limitations on production or imports for specific uses.

While the allocation of permits creates transfer payments to manufacturers using CFCs, this initial rent is at least partly offset by the reduction in the value of the capital equipment of CFC production facilities. A complementary tax to reduce such windfall gains has been implemented. In view of the potentially significant transfer payments involved, it is interesting to note that the EPA did not believe it had the authority to hold an auction for permits.

The CFC permit trading system is still in its early stages and it is therefore difficult to evaluate. Since the restrictions placed on trade and the administrative burdens of the controlled trading program have been largely eliminated, the system is predicted to have a good chance of success. An early study by NERA estimated that a

permit system would reduce the costs of compliance by approximately 50 percent compared to a direct control system.[9]

3.5 Proposed U.S. Acid Rain Permit System

A permit trading scheme for SO_2 emissions was recently approved as port of the new U.S. Clean Air Act. It is designed to promote reductions in SO_2 emissions from electric utilities. The distribution system proposed is a free allocation of permits based on historical production and emissions data, with reductions in the quantity of permits scheduled for 1995 and 2000. Trades will be largely unrestricted between sources; however, stringent new source performance standards still apply. There appears to be a wide consensus that the program will contribute to cost savings. The main areas of dispute were related to the distribution of permits and the potential for manipulation of the permit market.[10]

3.6 Conclusions

The experience with emissions trading in the United States has provided some insight into potential problems associated with market systems for environmental amenities as well as possible solutions to these problems.

Under the emissions trading program, great difficulty has been experienced in defining baselines and reductions from baselines, which in turn define emission credits. The difficulty in calculating these values has created uncertainty for polluters as to what surplus reductions will be recognized by state authorities. The costs which firms must incur to resolve such uncertainties serve to deter participation in the emissions trading market. Furthermore, the uncertainty as to whether property rights for emission reduction credits, once established, will remain with the source without discounts or confiscation by a state authority has also served to restrict market activity. On the other hand, the relative success of the lead trading market has been attributed, in part, to the creation of a market with clearly defined property rights for lead reductions.

A banking program which serves to identify potential buyers and sellers of emission licenses can alleviate the search costs involved in identifying potential external trades. Such costs inevitably act as a disincentive for firms to engage in trading of emissions, while they encourage firms to use emission credits for internal transactions. They also tend to limit trades to larger companies. High transaction costs

associated with the existing approval process for trades similarly discourage market participation and, consequently, cost saving potentials are not realized.

The degree to which trading of emissions is restricted by the regulatory constraints imposed on individual sources is an important determining factor of the success of any market approach to emission control. Ideally, under a market approach, those sources which can provide control at the least cost will be responsible for achieving emissions reductions targets. However, under the United States regulatory structure, new sources are required to maintain minimum levels of control, regardless of the costs involved. The imposition of a standard which makes distinctions among sources in this way creates rigidities in the control options, and the potential cost savings of the more flexible emissions trading approach are reduced. Finally, these case studies have illustrated that the market must be large and diverse enough to accommodate competitive trading, in order for cost efficiency to be achieved.

The experience with permit systems has reconfirmed the theoretical conclusions that success of the trading policy is contingent on an unrestricted, competitive permit market. Furthermore, the issues that are easily assumed away in theory, such as establishment of benchmarks, issue of property rights and intertemporal allocation, are potential stumbling blocks in practice.

- To ensure mutual net benefits from trading it is important to create a system with minimal transaction costs.

- It is equally important to eliminate, as far as possible, uncertainty with respect to transaction rules and government involvement. This contributes to well-defined property rights and, thereby, reduces the uncertainty related to present and future permit values.

This reinforces the general conclusion that a permit trading policy needs to be complete and well formulated at the outset to counteract the inevitable uncertainty of a real market. Permit trading for air emissions in the United States has historically been implemented as an add-on policy rather than as the central policy tool to reduce emissions. Canada has the option of incorporating a permit system at the policy design stage, thereby avoiding some of the bureaucratic complexities and uncertainties discussed above.

Footnotes

[1]Robert W. Hahn, "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders," *Journal of Economic Perspectives*, Vol. 3, No. 2 (Spring 1989), pp. 95-114.

[2]Robert W. Hahn and Gordon L. Hester, "Where Did All the Markets Go? An analysis of EPA's Emissions Trading Program," *Yale Journal on Regulation* (1989), pp. 109-153.

[3]Ibid.

[4]U.S. Department of Energy, *A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Change*, Vol. 1 (Washington D.C: U.S. Department of Energy, October 1989), pp. 4-14.

[5]Ibid.

[6]Hahn and Hester, "Where Did All the Markets Go?", 1989.

[7]Ibid.

[8]Ibid.

[9]David Harrison and Albert L. Nichols, *Emissions Trading: An Overview of Concepts and Experience*, Report prepared for NO_X/VOC Workshop on Flexible Mechanisms (Cambridge, Massachusetts: National Economic Research Associates, June 1990).

[10]Ibid.

Chapter 4

THE FEASIBILITY OF PERMIT TRADING FOR CO_2 EMISSIONS

In the case of a permit policy for greenhouse gases, the first decision must be whether to address the whole host of trace gases with this one policy tool, or whether other individual policies are better suited to target the various gases separately. Theoretically, the concept of a comprehensive greenhouse permit trading policy is appealing, as it would appear to address the entire problem with one simple and flexible policy tool at a minimum cost to society. In practice, there are several problems with such a comprehensive approach.

First, policies are already in place that target some of these trace gases. Specifically, as tropospheric ozone represents a local air-quality problem and CFCs contribute to stratospheric ozone depletion, permit trading for these gases could potentially cause conflicts with other environmental goals. For example, since CFCs are already scheduled for complete elimination, it would aggravate the greenhouse problem if CFC producers were allowed to trade or market greenhouse gas permits while phasing out CFCs.

Secondly, it would be very difficult to establish benchmark levels of emissions for some of the trace gases, particularly for methane and tropospheric ozone. As already mentioned, ground-level ozone is formed in the air rather than emitted, and this formation process depends on factors such as the ratio between emissions of nitrogen oxides and volatile organic compounds in the presence of sunlight and high temperatures. Methane sources are predominantly either fugitive or emitted from non-production related processes.

Finally, it is not a trivial problem to establish trading ratios between the gases. Although the relative heat-trapping potential by molecule can be readily established, these gases operate in different areas of the wavelength spectrum for radiated heat. While CO_2 is a very efficient heat absorber for certain wavelengths, increasing CO_2 concentrations alone would still leave the atmosphere transparent to heat radiation outside of CO_2's specific ranges. The other greenhouse gases are particularly efficient at absorbing heat in the ranges that CO_2 leaves transparent.[1] In a sense then, CO_2 and the other

greenhouse gases perform complementary, rather than additive, functions in trapping heat in the atmosphere. Thus reducing only CO_2 emissions will not solve the greenhouse problem, but it is difficult to establish appropriate trade-off ratios between the trace gases to allow for a comprehensive permit trading policy.

It must be recognized that a permit trading system would in any case only be part of a policy package to address greenhouse emissions. This case study is limited to CO_2 permits, but it does not preclude the possibility of expanding such a program to include all the greenhouse gases, providing the inherent difficulties can be resolved.

Another concept that requires clarification is the issue of net versus gross CO_2 emissions. If tree planting or creation of carbon ponds can reduce the net emissions from a source, such carbon sinks should be explicitly recognized so that any policy implementation is based on net CO_2 emissions. The problem is again a lack of sufficient and reliable scientific data on the carbon cycle to permit measurement and manipulation of such offsetting forces.

This chapter outlines the possible scope of a CO_2 emissions permit market and the characteristics of CO_2 emission sources, providing an assessment of how well the theoretical and practical conditions for successful permit trading are met in the case of CO_2. It does not constitute a full feasibility evaluation, since the question of economic impact is not addressed, and there are a number of practical issues that require further study. The purpose of the case study is to highlight and place such outstanding issues in their proper context and, as far as possible, outline the options available and the additional data necessary to choose the best solution.

4.1 The Scope of a CO_2 Permit Trading System

An important rule of thumb in policy design is that the policy should be effected at the level where the problem is felt. On a more pragmatic note, it is important that any particular issue is addressed at a level where authorities have jurisdiction to enforce the policy. In defining a CO_2 permit market, both these considerations must be kept in mind.

Climate change is inherently a global problem. The consequences of a warmer climate would certainly differ between sea level and interior lands and between equatorial and polar latitudes but,

while distributional effects are uncertain, no country or continent would escape the direct or indirect effects of global warming. In accordance with this, the greenhouse problem ought to be subject to a global policy. The relative insignificance of Canadian emissions in the global context have led to strong warnings that unilateral Canadian initiatives may cause severe economic dislocation without solving the problem. In fact, an overreaction that weakens the economy could make Canada more vulnerable to the effects of climate change and less able to contribute to an international solution, while domestic industries simply relocate to uncontrolled areas, leaving global emission levels unchanged.

The global nature of this problem is stressed in a comprehensive review of policy measures and their effectiveness by the International Energy Agency, which concluded: "Energy related measures which are confined to only part of the world are likely to produce disappointing results, even if they are really drastic".[2] Furthermore, the study states that: "Any measures which stand a chance of seriously affecting long-term CO_2 concentrations will be large scale and costly".[3] Coupled with the scientific uncertainty as to the timing and magnitude of climate effects, this reinforces the argument for caution and international cooperation in shaping a greenhouse gas policy.

As noted in Chapter 1, international negotiations over CO_2 emission targets are progressing, with the IPCC report to the Second World Climate Conference in November 1990 as the most recent milestone. In the meantime, the possibility of a global CO_2 permit trading program has been voiced both in Europe and North America. This leads to the issue of jurisdiction.

The practical success of a permit trading system is contingent upon a number of conditions, but of paramount importance is the ability to monitor and enforce the system and to agree on initial allocation. An international trading system would have to recognize each country's sovereignty and its right to formulate and enforce its own laws and regulations. Implementing permit trading on a global scale would still depend on endorsement and compliance by national authorities and enforcement of regulations at the national level. It is most realistic to assume that an international permit trading system is only a realistic option after national emission limits have been negotiated in international protocols and after a number of countries have gained some experience with this policy tool. Clearly, a national

permit policy is a prerequisite and not a hindrance to an international permit trading system. Extension of national programs to international trading is an option that can be explored through international negotiations or bilateral trade agreements.

The benefits of international trade in permits are obvious. By including a greater variety of sources and, in particular, a large number of low cost of compliance sources, the emission reductions can be achieved at lower overall costs of compliance. It would be particularly important in this respect to include developing economies in any international trade agreement. Emissions from non-OECD countries are expected to grow at much higher rates than emissions from the mature OECD economies, and it is crucial in the long run that these rapidly growing emissions be controlled.

It has been argued that an international permit system could also constitute a vehicle for development aid to third world countries. For example, by requiring that one tonne of CO_2 emitted in Canada be offset by actions, taken by Canada, to enable a 2 tonne reduction of CO_2 emissions in a developing country, permit trading would encourage transfer of wealth and technologies to developing countries. While this sounds like a policy that provides mutual benefits to all parties, and the wealth transfer would constitute a strong incentive for developing nations to participate, there are clearly problems with such a proposal. Establishing trade equivalence in permits would require lengthy international negotiations and the resolution of numerous measurement and enforcement problems.

Creation of CO_2 credits from reforestation is another potential extension of a permit trading system, national or international. The critical issue would be to ensure that reforested areas are maintained over time. It must also be recognized that as forests mature, net carbon absorption is limited, as the CO_2 released from decomposition and decay of plants and soil materials tends to balance the carbon uptake of new growth. The question of credits from reforestation must be addressed in the context of sustainable forestry, taking into account the entire cycle of logging and replanting.

Federal authorities have repeatedly stressed the desire for a cooperative approach to environmental control.[4] To ensure a sufficiently large market and to take advantage of cost variations, a permit trading system ought to be implemented at the national level. However, provincial and local authorities would have to play key roles

in ensuring appropriate allocations of permits and in establishing monitoring and enforcement mechanisms. These issues will be further explored in Section 4.3.

4.2 Characteristics of CO_2 Sources in Canada

As indicated in Chapter 1, man-made CO_2 emissions originate from a wide variety of sources, but fossil fuel combustion is of paramount importance. This section discusses the characteristics of CO_2 sources in Canada, in order to determine if a permit policy is a feasible option. Two of the most important conditions for such a policy to succeed were seen to be:

- a large enough number of participants to establish a competitive market for permits, but not so large that administration and enforcement are hampered; and
- a diversity of compliance options and hence of compliance costs to ensure sufficient cost savings so that trade is encouraged.

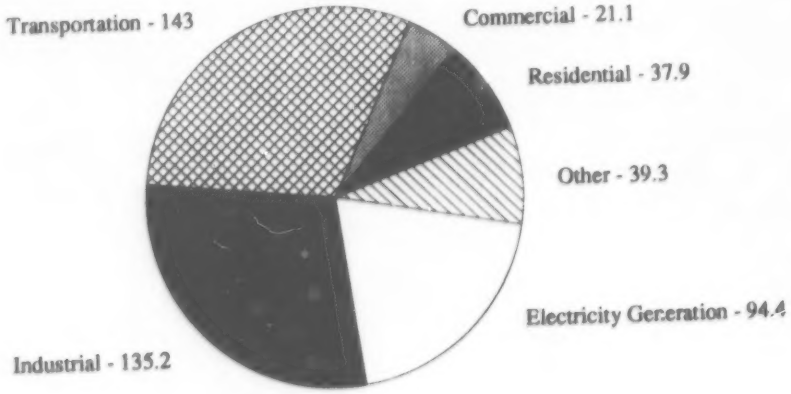
In addition, this review of CO_2 sources will serve to identify any special features that must be taken into account when designing a permit system, and provide an understanding of how energy use, and hence the emission profile of sources, might change with time. An overview of the potential participant sources is also the starting point for investigating regional economic impacts and the practical aspects of policy design.

According to Environment Canada, total Canadian CO_2 emissions in 1987 were close to 471 million tonnes. The main source categories are residential, commercial, industrial and the electric utilities sector. Figure 4.1 shows the relative size of emissions from each of these sectors. These emission numbers include non-combustion, industrial process sources and slash, wood, wood-waste and agricultural waste burning.[5] The numbers quoted should be treated as approximations, as they are based on specific assumptions with respect to average combustion efficiencies and carbon contents of fuels.

4.2.1 The Residential and Commercial Sectors

The residential and commercial sectors were responsible for approximately 38 and 21 millions tonnes of CO_2 emissions respectively in 1987, constituting 8 and 4.5 percent of the national total[6] (see Figure 4.1). Considering the large number of emission sources within

Figure 4.1
1987 Carbon Dioxide Emissions by Sector
(million tonnes)



Total = 470.9 million tonnes

SOURCE: Environment Canada, National Inventory of Sources and Emissions of CO2, 1987, June 1989.

each of these sectors, the individual sources become very small fractions of the total. Energy is primarily consumed for space heating and cooling, lighting, water heating and appliances; in other words, small, highly homogeneous emission sources.

Monitoring and enforcing a permit system for these sectors would entail an unacceptable administration and cost burden. Furthermore, since these equipment categories are fairly homogeneous, cost differentials across sources would be negligible, limiting the potential benefits of trade. Other critical features of this sector are that shortages cannot be tolerated for health and safety reasons, and fuel switchability is limited to the large commercial establishments.

For these sectors, a policy package consisting of standards for buildings and appliances, and conceivably energy taxes to provide economic incentives, are more appropriate environmental policy tools.

4.2.2 The Transportation Sector

Accounting for just over 30 percent, or 143 million tonnes, of national CO_2 emissions in 1987, the transportation sector is the single largest source of emissions[7] (see Figure 4.1). Individually, these sources are even smaller and more numerous than those in the residential and commercial sectors. The mobile nature of transportation sources is of greater concern for local air quality management than for a uniformly mixed pollutant like CO_2.

For fleet vehicles, the most promising option for reducing greenhouse gas emissions would appear to be the adoption of alternative transportation fuels. There are a number of alternative transportation fuel options available, at varying stages of commercial application, ranging from compressed natural gas and propane to ethanol and methanol. Fleet vehicles are in a position to take advantage of economies of scale in fuel efficiency and conversion and to establish central filling stations.[8]

For the private vehicle segment of this market, there are alternative policies such as fuel efficiency and emission standards, fuel and vehicle taxes, and deposit/refund programs for cars. Unfortunately, vehicle standards are only a partial solution to emission problems, since emissions will still increase with increasing travel. This becomes primarily a demography and lifestyle issue. A full

solution must involve elements of land use policy, public transportation, education and moral suasion.

4.2.3 The Industrial Sector

Purchased fuel combustion in the industrial sector was responsible for approximately 70 million tonnes, or 15 percent, of Canada's CO_2 emissions in 1987. In addition, industrial processes such as cement and ammonia production and burning of spent pulping liquors in the chemical pulp industry are large sources of emissions, accounting for an additional 41 million tonnes, or 8.8 percent of the national total. Gas plant and field use of fossil fuels account for another 23 million tonnes, or 5 percent, bringing industrial emissions to 135 million tonnes, or almost 29 percent of Canada's total emissions in 1987[9] (see Figure 4.1).

The industrial sector is a natural choice for a CO_2 permit trading program. The sources are generally large and well defined, and yet they fulfill the criteria for establishment of a competitive market. As noted earlier, the other major condition for a successful permit program is the existence of sufficient variations in costs of control to generate benefits from trade. As the benefits from trade may vary substantially between sources, the transfer payments resulting from a permit trading system may have important regional economic implications.

The remainder of this section will provide a brief overview of the types of CO_2 control technologies, first generally and then by industry, available to the large energy-using industries in Canada.

4.2.3.1 Options to Control CO_2 Emissions

There are a number of generic control options that will increase the efficiency of energy use and thereby contribute to emission control. Combustion efficiency, waste heat recovery, housekeeping measures, insulation, and general process control are examples of this. It becomes more complex to trace the changes in emissions from fuel switching, development of alternative fuels, cogeneration, non-utility generation options, and energy cascading, since the total emission changes must take into account all the indirect effects for other emissions sources as well as the effect at the primary emission source.

It is possible to recover CO_2 from flue gas, but this control option is constrained by fairly prohibitive costs, since CO_2 by volume

constitutes a relatively small portion of the flue gas. Different technological options also exist for recirculating and enriching the flue gas, to make the CO_2 stripping process more efficient. The ultimate challenge for CO_2 recovery technologies, however, lies in an adequate disposal method. Recovered CO_2 can be liquified and transported to another location for disposal or alternative use but, whether the CO_2 is disposed of in underground storage, used for enhanced oil recovery or in other production processes, care must be taken to ensure that it is not eventually emitted into the atmosphere.

When reviewing the individual industries, it is important to keep in mind that the energy requirements, and hence the emission profiles, will change as a consequence of process changes that are ultimately driven by product market signals. Demand for more highly refined or specialized products and international competition are the kinds of forces that will really influence total emissions. Utilization of energy, raw material and capital inputs are subsequently adjusted in the production process within the bounds of what is technologically possible.

4.2.3.2 The Pulp and Paper Industry

There have been substantial efforts made in improving energy efficiency, especially for purchased energy, in the pulp and paper industry. Between 1972 and 1989 the industry reported well over 30 percent improvement in energy efficiency, measured as purchased energy per tonne output.[10] While most of the simple housekeeping efficiency measures have been implemented, there is still potential for improvement in energy utilization. Among the pure energy conservation opportunities remaining are continued improvements in burner and boiler efficiencies and waste heat recovery and upgrading, the latter related mostly to steam applications.

Past trends in energy use have shown a high degree of substitution towards self-produced waste fuels. This has now stabilized at around 67 percent of total energy use, but it is expected that this substitution will be pushed further in the future as a result of ongoing research efforts.[11] Considering the size and energy-intensity of this industry, a high and growing share of self-produced fuels must be taken into account when designing a permit program. The variable carbon content, dryness and efficiency of combustion for fuels such as wood-wastes, pulp and paper sludge and black liquor means that CO_2 emissions are fluctuating and difficult to measure.

Another area of uncertainty is with respect to purchased electricity. Even when disregarding electric boilers, which were largely installed in response to Hydro Quebec's conversion programs in that province, electricity's share of total purchased fuels has risen from 24 to 35 percent between 1972 and 1988.[12] This trend is expected to continue into the future as mechanical pulping technologies continue to replace sulphite and other chemical processes. Advanced chemical recovery technologies such as plasma gasification, mechanical vapour recompression and membrane separation all require higher electricity inputs. If high or even medium consistency pulping is introduced, pumping requirements for the pulp mass through the process stages will increase. The consequence of these changes for CO_2 emissions depends on how the increased electricity demand is met. Whether electricity is generated on-site or purchased, the choice of generation technology becomes the crucial question, and the generation stage must be taken into account when measuring changes in net emissions.

4.2.3.3 The Cement Industry

Even aside from the fuel combustion process in the cement kilns, this industry is a major source of CO_2 emissions as carbon is required for the chemical reactions in the calcination process. This industrial process source alone accounted for almost 6.3 million tonnes of CO_2 emissions in 1987, or 1.3 percent of the national total.[13] Emissions per tonne produced are not likely to change radically in the future.

With respect to fuel consumption, the main characteristic of cement manufacturing is the high degree of flexibility in fuel choice. Direct price competition is the determining factor in fuel demand. Without an economic penalty for emissions, cheaper and dirtier fuels have an advantage. The adoption of the dry process was a source of substantial efficiency improvements in the past and further, less substantial, energy efficiency improvements will continue with additions of preheaters and precalciners and with new kiln structures.

4.2.3.4 The Chemical Industry

There are both combustion and process related sources of CO_2 from the highly diverse processes involved in chemical manufacturing. For industrial chemicals, efficiency measures have contributed to more than 40 percent energy intensity reductions since 1972.[14] These improvements have exhausted most of the low-cost conservation options. Technological advances, especially in the areas of sophisticated process optimization and monitoring equipment,

continually enhance both process control and flexibility, and open the way for new conservation potentials. The chemical industries also carry a large, unexploited potential for cogeneration. Taking advantage of cogeneration opportunities would further improve the energy efficiency of production and, with respect to the ultimate impact on emissions, it would also make an important contribution to electric utilities' demand management strategies.

Manufacturing ammonia for fertilizers is also a major non-combustion source of CO_2. Fertilizer production accounted for in excess of 4 million tonnes of CO_2, or 0.86 percent of total national emissions in 1987.[15] The CO in the reformed natural gas (synthesis gas) must be removed to avoid contamination of the ammonia catalyst and this is accomplished by shift conversion of CO to CO_2. The cost of capturing this CO_2 is unknown, and the major problem of affordable and permanent disposal is again a complication.

4.2.3.5 The Iron and Steel Industry

Structural changes in the iron and steel industry have made energy efficiency changes erratic. Economic factors such as over-capacity, variable scrap availability, changes in the degree of process refinement and various process interruptions have characterized this industry over the last decade. Generally, the trend is towards improved automation and integration of the steel making process as witnessed by the penetration of continuous casting and hot-charging of semi-finished products. This trend will continue over the long-term, with commercial development of direct reduction, direct smelting, direct rolling and thin steel casting.

Emissions from fuel combustion will decrease as the heating and reheating requirements of these integrated processes are reduced. Increasing proportions of scrap in steel-making can also drastically reduce the fuel requirements involved in producing virgin steel.

4.2.3.6 Petroleum Exploration, Development and Production

Because the petroleum industry's CO_2 emissions come from such diverse sources as gas flaring or venting, producer consumption and losses of energy, as well as regular stationary and mobile equipment sources, gathering consistent data presents a difficult problem for this industry. Environment Canada's CO_2 inventory indicates that gas plant and field energy consumption was responsible for 23.3 million tonnes of CO_2 in 1987, which accounts for almost 5

percent of emissions at the national level.[16] Of this total, 19.5 million tonnes were emitted in Alberta, according to the national inventory. A more detailed and comprehensive inventory of CO_2 emissions for the petroleum industry in Alberta indicates a total of approximately 26.5 million tonnes in 1988.[17] This higher number includes categories such as flaring, processing and pipeline consumption of gas, and gas and refined petroleum products consumption by oil fields, oil sands operations and refineries. In addition, there are necessarily leaks and losses involved at all stages of the petroleum supply industry, although substantial efforts have been made to minimize these.

The industry is faced with a growing challenge as the supply of crude feedstocks gets heavier while the demand for light-end products continues to increase. The Alberta CO_2 emission forecast reflects this, as annual emissions are projected to increase by almost 37 percent above current levels by year 2005. The main driving force behind this increase in emissions is the expansion of oil sands production.[18]

At the refining stage, larger proportions of heavier and synthetic feedstocks require increased process severity and complexity. This also contributes to higher energy intensity and increased CO_2 emissions. Offsetting this trend is the continued effort towards conservation. Efficiency improvements can be accomplished by measures ranging from housekeeping and heat recovery to high efficiency burners and furnaces and advances in process control systems. There is very little scope for fuel switching in this industry, except between self-produced refinery gas and purchased natural gas, which depends on the total process gas requirements and the availability of refinery gas. More complex and highly integrated refineries involve increased motor and pumping drive requirements, a trend which will tend to cancel out efficiency improvements in electricity end-use.

In conclusion, it appears that options to constrain the growing CO_2 emissions from the energy supply sector are limited. As oil producers are faced with declining conventional and light reserves and, simultaneously, are required to satisfy a growing demand for light products, refining processes must become more severe. To the extent that end-use markets address their emission problems through fuel switching, away from oil and coal towards natural gas, natural gas production and processing will increase. It appears that this sector needs to continue to explore the possibilities of CO_2 recovery and disposal as control options for emissions.[19] The venting and flaring of

natural gas is perhaps the most immediate area where control measures could be implemented, provided adequate and economical disposal options were developed.

4.2.3.7 The Aluminum Industry

Although a large energy consuming industry, aluminum is primarily electricity intensive. Fossil fuels consumed are mainly coke and pitch required to produce carbon anodes for electrolysis of alumina to aluminum. This creates a small process source, as opposed to a combustion source, of CO_2 emissions. Aside from smaller efficiency improvements, no major process changes are foreseen for this industry.

4.2.3.8 Conclusions

The CO_2 sources in the industrial sector appear to be a natural choice for a potential permit trading program. Representing approximately 29 percent of total CO_2 emissions in Canada, the sector is large enough to ensure a competitive permit market and diverse enough to provide sufficient variations in cost of compliance for trading to be beneficial.

If trading is limited to the large sources, these must be selected according to a consistent criterion. Statistics Canada categorizes in excess of 200 firms as "large industrial energy users".[20] These firms own plants that are responsible for approximately 75 percent of industrial energy consumption, but this does not necessarily correspond to 75 percent of industrial CO_2 emissions. The actual share of total industrial emissions depends on the relative distribution of fuel and electricity shares between large and small energy users, since fuel combustion is the primary source of emissions. One would expect that the large users category consumes more than its share of the heavier, high-emissions fuels but, on the other hand, some very large and energy intensive industries, notably smelting and refining, are highly electricity intensive. As a rough estimate, it seems reasonable to assume that, when process sources are included, at least 20 percent of Canada's CO_2 emissions would be accounted for in a permit trading system for the large energy-using industries.

The review of the most energy intensive industries illustrates how each is faced with very different economic and technological conditions. It also reveals some important energy-use characteristics that must be taken into account if a permit market for CO_2 is established. **First, it would not be sufficient to base CO_2 emission**

calculations on purchased energy volumes alone. Most of these industries consume large volumes of self-produced fuels, varying from black liquor and hog fuels to coke, refinery gas and methane. The combustion of these fuels constitutes a significant emission source and must be included for a permit system to be effective. The high degree of variability in these fuels could greatly complicate the task of monitoring emissions.

Secondly, production processes, even within the same industry, are highly diverse and depend on factors such as age and structure of capital equipment, raw material constraints and distance to markets. This will complicate the practical aspects of monitoring and enforcing an emission policy.

Finally, a major area of uncertainty for future emission profiles of industries lies in electric power generation options. To the extent that industries exploit non-utility generation options, in particular cogeneration, the pressure on electric utilities to comply with emission limits will be relieved through lower demand growth. The trend to increasing electricity intensity in production will otherwise add to the supply pressure on electrical utilities. To retain control over total emission levels, if a permit system includes the industrial sector it must also include electric utilities to avoid an incentive to simply shift emissions from a regulated to an unregulated sector.

4.2.4 The Electric Utility Sector

Contributing approximately 20 percent of national CO_2 emissions or 94 million tonnes in 1987, the electric generation sector constitutes another major emission source.[21] Compared to many other Western countries, the contribution of electric utilities to CO_2 emissions is relatively minor because of Canada's high reliance on hydroelectric generation, representing almost 57 percent of total generation capacity. Canada, or specifically Ontario, also has significant nuclear generation capacity. The diverse resource base and geographic characteristics of Canada's provinces have led to very different mixes in generation capacities across the country. Table 4.1 shows Canadian generation capacities by fuel and province, illustrating the variations both in the absolute size of the sectors and in the generation mix across the provinces. Ontario and Quebec alone account for 60 percent of total Canadian generation capacity. Quebec, Manitoba and British

TABLE 4.1

INSTALLED GENERATING CAPACITY BY FUEL TYPE AND PROVINCE 1988

	Hydro		Coal		Nuclear		Oil		Natural Gas		Total
	MW	%	MW	%	MW	%	MW	%	MW	%	MW
Nfld.	6 644	89.5	0	--	0	--	782	10.5	0	--	7 462
P.E.I.	0	--	20	14.1	0	--	122	85.9	0	--	142
N.S.	386	16.5	1 201	51.2	0	--	758	32.3	0	--	2 345
N.B.	903	26.0	356	10.3	680	19.6	1 532	44.1	0	--	3 471
Que.	25 585	93.9	0	--	685	2.6	980	3.6	8	--	27 258
Ont.	7 775	23.6	10 935	33.2	11 221	34.0	2 651	8.0	373	1.1	32 955
Man.	3 641	88.3	466	11.3	0	--	14	0.3	4	0.1	4 125
Sask.	832	29.2	1 554	54.6	0	--	27	0.9	432	15.2	2 845
Alta.	734	9.7	4 979	65.5	0	--	15	0.2	1 872	24.6	7 600
B.C.	10 848	86.8	0	--	0	--	246	2.0	1 403	11.2	12 497
Yukon	82	56.6	0	--	0	--	44	30.3	19	13.1	145
N.W.T.	54	30.9	0	--	0	--	121	69.1	20	11.4	195
Canada	57 484		19 511		12 586		7 292		4 111		101 004

SOURCE: *Electric Power Statistics, Volume II*, Statistics Canada, Catalogue 57-204, Energy, Mines and Resources Canada.

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Que.	25 585	93.9	0	--	685	2.6	980	3.6	8	--	27 258
Ont.	7 775	23.6	10 935	33.2	11 221	34.0	2 651	8.0	373	1.1	32 955
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Canada	57 484		19 511		12 586		7 292		4 111		101 004

SOURCE: *Electric Power Statistics, Volume II*, Statistics Canada, Catalogue 57-204, Energy, Mines and Resources Canada.

Columbia are heavily reliant on hydro power, while thermal, coal-based generation is the dominant technology in Alberta and Saskatchewan.

In a recent CERI study investigating critical issues in electric power planning, it was concluded that in the face of increasing demand- and supply-side constraints: "Comprehensive least-cost planning and competitive bidding for new supply seem destined to become fundamental in Canadian electric power planning".[22] The study concluded that: "if demand grows at the rate presently forecast by utilities, we expect a requirement for some 9000 MW of new, uncommitted capacity by the year 2000", and "in all of the scenarios developed, the rate of construction of new capacity in Canada is considerably greater than that experienced in the past decade".[23]

If the future generation mix remains similar to that for existing capacity, a concerted effort will be necessary to reach the CO_2 target Canada has committed to. Utility strategies to improve energy efficiency and reduce emissions include options reviewed briefly below.

4.2.4.1 Fuel Switching

Switching to a low-carbon fuel, for example from oil or coal to natural gas, is an obvious way to reduce CO_2 emissions. It is difficult to predict to what extent utilities will undertake this kind of switching. In general, it is more likely that capacity additions will be based on a different fuel source than that current capacity will be converted. In a broader perspective, a strategy to increase reliance on nuclear or hydro capacity would constitute a form of fuel switching. Canada still has a considerable hydroelectric generation potential, perhaps as much as 50 000 MW.[24] Many of these projects would be smaller and located in remote areas, and may be more economically exploited as non-utility options than as part of utility capacity.

4.2.4.2 Combustion Efficiency

Advances in combustion technologies range from new burner designs to new combustion technologies. While many advanced combustion technologies have not yet reached the stage of commercialization, they promise a scope for continued improvements in both energy efficiency and emissions in the future. A complicating factor is that electric utilities are also targets for NO_x and SO_2 emission reductions. While energy efficiency improvements will reduce all emissions, traditional technology solutions to reduce acid emissions, such as SO_2 scrubbers, may actually increase energy use, and thereby also increase

CO_2 emissions. The latest technological developments in fossil fuel combustion have demonstrated that options such as clean coal technologies can increase plant efficiency from 35 percent in a conventional thermal coal-fired plant to as much as 60 percent with advanced combined-cycle and fuel cell generation.[25] Even greater efficiencies are possible with advanced gas turbines.

4.2.4.3 End-Use Efficiency

As illustrated in the discussion of industrial emission sources, there remains considerable potential for energy efficiency improvements in the end-use of energy. In the industrial sector, high efficiency and variable-speed motors are specific examples of energy efficiency technologies. In general, more efficient heating, cooling and lighting can contribute greatly to conservation of electricity. To explore and exploit such efficiency improvements, Canadian utilities have to various degrees committed to demand-side management (DSM) projects. It is expected that DSM will play an increasingly important role in controlling both the size and the shape of electric utilities' load curves in the future. In Ontario, DSM programs are expected to reduce effective utility demand by as much as 60 percent by the year 2000.[26]

4.2.4.4 Non-Utility Generation

Another option for least-cost utility planning is to encourage non-utility electricity generation. The industrial sector still has a largely unexploited potential for cogeneration which not only represents an alternative generation source, but which contributes to overall energy efficiency improvements. The development of non-utility generation options depends critically on utility pricing policies relative to interruptible power prices and buy-back rates.

4.2.5 Delineating a CO_2 Permit Market

The large industrial energy users and the electric utility sector are the CO_2 sources best suited for a permit trading system. These sources would likely be represented by less than 300 firms, although they account for a much larger number of plants. Without having access to detailed definitions and data, a rough estimate is that these sources would cover at least 40 percent of national emissions, assuming that approximately 75 percent of industrial sector emissions could be included. **The first step in further pursuing this policy**

option would be to determine the level of emissions for which the sources would require permits, and to conduct a detailed analysis of participants.

In theory, there are several potential problems involved in limiting the market to only large emission sources. If there are a large number of small sources, large source control alone might not be a sufficient response. **For this case study, estimated coverage would appear to be sufficient to make permit trading a viable option, although other complementary policies would be required to address the residential, commercial, transportation and small industrial sectors.** Large source control may also lower the cost-efficiency of the market solution. If the smaller industrial CO_2 sources represent a significant number of low cost-of-compliance options, their exclusion would be detrimental to the cost efficiency of the policy. These foregone opportunities must be weighed against the additional costs associated with administrating and enforcing permits for the additional smaller sources.

A second potential difficulty with large source control lies in the possibility that firms may be able to shift their emissions from the regulated to the unregulated sector. Vertical integration of companies and economies of scale in production would work against such shifts. No indication has been found in the U.S. experience with large source control that such emission shifts have caused an overall deterioration of air quality but, as a potential problem, it should be closely monitored.

From the cursory overview of industrial and electric utility source characteristics, it appears that the permit market would encompass a diversity of compliance options and that cost variations would also be sufficient to generate substantial benefits from trade. Again, detailed analysis of the costs of compliance and of the resulting intra- and inter-industry permit trade patterns is recommended, both to confirm the magnitude of potential cost savings and to outline the regional impact of such a policy.

A feature that may complicate the establishment of a permit market emerges from the discussion of source characteristics, namely, the heavy reliance of energy-intensive industries on self-produced fuels. Clearly, a policy that addresses only purchased fuels would not be a sufficient response to an emission problem. This would be a serious problem if an emission tax policy was pursued. Furthermore,

self-produced fuels commonly have highly variable dryness and carbon content, which can greatly complicate the problem of monitoring emissions.

Given this rough outline of the participants in a potential CO_2 permit market, it is possible to consider the practical problems of implementation, administration and enforcement. Again, without specific data on industry emissions and costs of control it is not possible to recommend actual emission benchmarks and allocation formulae. This analysis serves primarily to place these practical problems in context and underline the necessity for further data and research.

4.3 Implementing a Permit System for CO_2

The theory of permit trading conveniently assumes full and instant knowledge of volumes of emissions at all times and from all sources, and absolute compliance with regulations. In practice, implementing a policy and ensuring compliance can be a very complicated matter.

In principle, an emission permit system will achieve an aggregate emissions target at least cost under competitive conditions. This theoretical advantage of a system for trading emission permits is attributed to the ability of pollution sources to freely transfer these permits among themselves. Such transferability provides the incentive for all sources to accept control responsibility to the point where their marginal control costs are equalized, so that a minimum commitment of resources is assigned in the market to abatement control.

It is important to note that this result is dependent upon the operation of an emissions permit market in the purest sense. In other words, the market authority would only determine the cap on total emissions within a specified geographic region. In terms of market rights, all sources would be treated equally with no distinctions made on the basis of age or type of industry. Sources would be allowed complete flexibility in their control options with no additional regulations requiring them to maintain minimum standards. Approval by the control authority of methods of control would not be required, nor would the distribution of permits resulting from trade be subject to constraints.

In reality, some regulatory interference in the market is inevitable. In fact, it will be essential in order for the government to adequately monitor and enforce the system. Again, to preserve net benefits of trade it is critical that the scope of government involvement is clearly defined and understood at the outset.

In addition to a well defined regulatory framework for the permit market, strategic behaviour of companies leading to limited transferability of permits must be curtailed. The practical experience with permit trading suggests that hoarding permits or conducting only internal trades can serve as barriers to entry for new companies. Such behaviour can seriously limit the transferability of permits.

To the extent that the underlying assumptions for permit trading are not fulfilled in reality, the cost-efficiency of a permit trading system is undermined, and a least-cost solution to emission control becomes unattainable.

4.3.1 Establishing Benchmarks and Allocating Permits

The first decision to make with respect to allocation is to choose between an auction and a free distribution system. There were seen to be essentially three reasons for choosing an auction system over free distribution of permits:

- to raise government revenue;
- to correct for strategic behaviour; and
- to gain full information on the marginal costs of control by source, allowing authorities to calculate an aggregate demand curve and an equilibrium price for permits.

If raising government revenues is not an objective, a lump-sum refund method can be introduced. Again, the auctioning method must be designed so as to ensure that strategic behaviour does not influence the distribution system.

With a CO_2 permit market of the magnitude outlined above, the large number of sources involved would ensure a competitive permit market. However, determining a method for free initial distribution of permits remains a major problem. Wealth transfer resulting from initial trade could have important regional economic impacts, and it must be expected that both municipal and provincial authorities as

well as industry lobby groups will promote their special interests. **The theory section demonstrated that without full information on costs of compliance by source, which would allow a distribution that could at least come close to equalizing marginal costs, any formula adopted will involve a politically sensitive decision based on a notion of equitable transfer payments.**

The design of a formula for distribution is further complicated by the fact that the sources involved produce a wide range of products. The allocation method must be able to distribute permits both between the various industries and among firms in each industry. **In other words, while a CO_2 per tonne output measure may serve to allocate permits when the output is a homogeneous product, it is not feasible to use such a physical measure across highly diverse products.**

Some options for an initial distribution formula are discussed below. The list is intended to be illustrative and is not by any means an exhaustive presentation of options.

4.3.1.1 Distribution by Current Emissions

Any environmental policy requires that current emissions can be measured by source, both to assess the pollution problem and for the purpose of monitoring and enforcing a policy. As discussed in the theory section, a distribution of permits by current emissions would be equitable if current emission control efforts are distributed so that marginal costs are equal across sources. In other words, if the policy is implemented in an equilibrium market where each company has invested in CO_2 control measures up to the same marginal costs, initial distribution by current emissions would be transfer neutral. In reality, the CO_2 sources have already committed considerable resources to energy efficiency improvements.[27] If this distribution method is considered, additional investigation into the likely trade pattern and the resulting equity issue would be required.

The main arguments in favour of such a distribution scheme are:

- If the policy goal is to freeze CO_2 emissions at current levels, no cut in current emissions needs to be negotiated.

- The data on current emissions is required for enforcement of any emissions policy; therefore, no further information is needed.
- Detailed data on costs of control by source is not required to distribute the permits.
- The direct link to volume of emittants makes the policy easily understood and therefore politically attractive.

The drawbacks of such a distribution scheme are:

- The efforts of companies that have in the past committed relatively more resources to CO_2 control or energy efficiency improvements than the average are not recognized. They are treated on the same basis as polluters that have made no efforts. Past achievements are not rewarded.
- A company that has had a sub-normal year with low production, but is poised for growth, would be allocated permits on the basis of low emissions and would face higher costs of expansion.
- Although source cost information is not required to allocate permits, it is needed to analyse the equity of this distribution method prior to implementation.

If cuts from current emission levels are required right from the start of the program, the equity problems will be exacerbated. Companies that have high marginal costs of control because of previous investments in emissions reducing technologies will be required to share in the cost of emission reduction with low-cost, low-control companies. In theory, such companies could actually reduce their level of control and purchase permits at a lower cost than the cost of installing additional control technologies. The fact remains that they are faced with a net cost increase. In addition, the assumption that cost savings can be realized by reducing the level of control is not realistic, since capital equipment in place cannot, at least in the short run, be divested without incurring additional costs.

4.3.1.2 Distribution by Value Added of Production

An alternative method of allocation would be to distribute permits by the value added of the output produced. This method is essentially a variant of the emissions per unit output formula, with the advantage that value added is a measure of production that can be applied across all industries.

The key points favouring this distribution method are:

- The formula would be relatively easy to apply. It can be used for distribution across different industries and among the firms in one industry. The value added concept is established and understood, and the data is readily available.

- This distribution favours those industries that contribute the most to Canada's economy and would act as an incentive to the domestic manufacturing industries to further refine and upgrade their products.

On the other hand, the scheme would create certain inequities:

- Distribution by value added is not directly tied to actual emissions, and low value-added, high emission industries would carry a disproportionately high burden of compliance costs.

- This burden may be perceived as particularly difficult and unfair for primary resource industries in single-industry regions.

4.3.1.3 Distribution According to Industry Benchmarks

The U.S. limited emissions trading program distributed permits in accordance with individual industry standards. If an industry average or desired emissions standard can be calculated, firms below this standard can sell excess permits and firms not in compliance can choose between investing in control technologies or purchasing permits in a cost-minimizing manner. This method, again, has distinct advantages and disadvantages. On the positive side:

- The method is directly linked to emissions. As a combination of conventional standard setting and a market-incentive policy, it would strike a compromise that may be more politically acceptable and easily adapted to existing standard-based policies.

- Detailed cost information by plant would not be required. The burden of proof of compliance would be on the company that does better than the standard and wishes to sell excess permits.

- The allocation method would be perceived as "fair" in that it rewards low emission plants and penalizes high emission plants within an industry.

On the other hand, establishing such benchmarks is not without difficulties:

- It would be difficult to reconcile the overall goal of reducing emissions by a specific quantity with the individual industry benchmarks. The policy does not prescribe a method for initially distributing emission cuts between the various industries.

- Setting the industry benchmarks would be a challenging and controversial exercise. There are very significant process differences within what may be perceived as a homogeneous industry. The first step would be to design categories by end products within each industry, for example, raw steel equivalent or semi-finished steel slabs, that require approximately the same degree of processing. Then a baseline for emissions in each category must be calculated. This would require significant effort and data.

- Even for homogeneous products, process differences caused by factors such as raw material availability, plant layout and age of capital equipment can contribute to significant emission differences. To place a higher cost burden on emitters who do not initially comply with their industry baseline cannot automatically be assumed to represent a "fair" distribution of costs.

- The U.S. experience indicated that a hybrid of regulations and permits could carry a high administrative burden and discourage the establishment of an active permit trading market. The more complex the initial allocation method, the more likely it is that the inherent advantages of permit trading, namely flexibility and cost-effectiveness, will be eroded.

Obviously, there are an endless number of options for an allocation formula. The overriding conclusion with respect to permit allocation is that if permits are not allocated to equate marginal costs of compliance, a thorough evaluation of the implied equity distribution and transfer payments between sources is required prior to implementation. In addition, authorities may consider withholding a certain number of permits, in order to be able to intervene in the market without changing the basic regulatory framework.

4.3.2 Monitoring and Enforcing

While a control policy may be cost effective under the assumption of perfect compliance (or perfect enforceability), less cost

effective control approaches may be more desirable when the difficulty of the enforcement task and the associated costs are considered. **The question which needs to be addressed is whether a permit system for CO_2, as opposed to a less cost-efficient regulatory approach, will increase or decrease the difficulty of the enforcement task. It may be misleading to evaluate the desirability of alternative control approaches under the assumption of perfect enforcement.**

In terms of information requirements, the minimum requirement to enforce any emission policy is to be able to establish emissions by source. The source characteristics determine to what extent continuous monitoring is required. If emissions are fixed for a certain type of capital equipment, the installation of that equipment represents sufficient emission control. However, this is rarely the case in production processes. Insufficient maintenance or sub-optimal capacity utilization can often change the emissions profile of a process. To the extent that operating costs can be reduced by reducing the operating capacity of control equipment, there is an incentive to increase emissions unless a continual monitoring process is in place. This may well be the case for CO_2, since these emissions depend directly on the energy efficiency of production. Efficiency changes can certainly be induced by using any equipment at either less or more than optimal capacity.

The question of monitoring also needs to be addressed at the policy design stage. If the sources themselves are not required to monitor emissions, there will be no incentive for them to structure the production process to facilitate monitoring and, as a result, enforcement becomes both difficult and costly. A permit system must include a monitoring and reporting requirement to ensure that source emissions can be checked.

Perhaps the most serious difficulty associated with enforcement under a market approach to control is the verification of equivalence of emissions trades. When emissions trading is implemented, control authorities are faced with the additional task of determining equivalence in emissions volume changes resulting from the control measures assumed by all sources engaging in trade. In other words, the equivalence of emission decreases for sources selling emission permits, and emission increases for those sources purchasing emission permits, must be established.

This task requires that an accurate emissions inventory be provided to the control authority in order to determine the amount of emissions contributed by each source to the air-shed before trade is initiated. These inventories serve as a baseline for calculating any reduction credits. To the extent that they reflect inaccurate values, there is potential for actual increases in emissions into the air-shed and associated deterioration of air quality. Specifically, if a baseline for one source is established above the actual level of emissions, the source will qualify for a reduction credit even though no reductions have occurred.

The cost-minimizing firm under conditions of imperfect enforcement will weigh the costs of compliance against the costs of noncompliance. Costs of compliance will include the costs of meeting an imposed standard, either through investment in control equipment including the associated operating costs or through the purchase of permits, and the costs of verifying compliance through a monitoring process. To the extent that these values exceed the penalty of noncompliance, which will depend on the likelihood of detection and size of sanctions, it creates an incentive for sources to remain in noncompliance as a means of minimizing their total costs. Many examples of successful attempts to relax standards, either by lobbying or through court actions, exist in cases where imposed regulations have been perceived as excessive.

Improved monitoring may be ineffective if penalties for noncompliance are not enforced. Historically, penalties have rarely been applied since they are seen to create friction between sources and control authorities. In the U.S., this has led to extended court battles on the grounds that imposition of standards is economically too burdensome. Furthermore, penalties have failed to raise costs of noncompliance sufficiently to encourage compliance. Ideally, penalties should be established such that no cost advantages can be realized from noncompliance. This would require that the cost savings which a source enjoys by noncompliance are included within the penalty.

A permit trading system is, at least theoretically, a means to reduce the costs of compliance. To the extent that the costs of controlling emissions are reduced under this policy, the incentive to remain in noncompliance is also reduced. This is the most important advantage of a market-incentive policy with respect to enforcement.

Further analysis of source characteristics is necessary to determine the extent and continuity of monitoring required to ensure

control of CO_2 emissions, keeping in mind the possible variations in emissions from changing operating characteristics. **In conclusion, a permit policy must be designed to ensure an adequate monitoring and reporting procedure, including a method for verifying the equivalence of traded emissions, and must carry a noncompliance penalty that provides sufficient incentive to comply with regulations.**

4.3.3 Duration of Permits

The success of the U.S. lead permit trading system for refineries was partly attributed to the lack of confusion over ownership rights and general confidence that the authorities would not change the regulations once implemented. This could chiefly be attributed to the well-known duration and intention of the program. Lead was set to be phased out over a specified time period, and permit trading was selected as the policy to achieve that goal.

In order to achieve the same success for a CO_2 permit trading program, the goal of the policy should be explicitly stated and the duration of permits designed accordingly. The problem with identifying and committing to a CO_2 emissions goal is that under current technological constraints, CO_2 cannot be eliminated. The adoption of a target will represent a compromise between economic burden and environmental damage.

In view of this inherent uncertainty with respect to the goal, it becomes even more important that the duration of CO_2 permits is fixed, so that the uncertainty with respect to property rights is not compounded. It is likely that authorities will wish to withdraw a certain quantity of permits from the market, in order to tighten standards over time. This can either be accomplished by authorities purchasing at market price and subsequently retiring the desired quantity, or by giving permits a specific duration and re-issuing a smaller number at the expiration date.

A degree of flexibility can also be introduced by having the issuing authority act as a permit broker or allowing private agents to fulfill this role. This can aid in reducing the transaction costs of a trading system and provide buyers and sellers of permits with an additional degree of flexibility.

In spite of the flexibility potentially provided by government participation in a permit market, it is recommended that permits be

given a fixed expiration date. The desired life of a permit must be set in accordance with the timetable for policy review, so that standards can be tightened at expected, scheduled intervals.

Specific dates for permit re-issue must be decided in connection with the method of allocation, weighing the economic and administrative costs as well as the inequities of allocation against the desire for frequent policy revisions. Thought should also be given as to whether the allocation method used when re-issuing permits should differ from the initial allocation process. To the extent that a permit policy is successful, it serves to equalize marginal costs of abatement. If these marginal costs are equal at the time of re-issue of permits, it is possible to allocate in accordance with current emissions without creating a further incentive to trade. **However, the system must be designed to ensure that the intertemporal decisions of emissions source owners are not inappropriately influenced by the expectation of future re-issue methods.** The specific duration and the methods and timing for retiring and re-issuing permits are important elements of a well-defined permit system. Outlining these conditions from the start is critical for defining the value of permits.

4.4 Limitation of the Case Study Analysis

This chapter has provided a preliminary analysis of the feasibility of establishing a CO_2 permit trading system in Canada. Given the current state of available emissions data and the scope of this study, the intention was not to provide a blue-print for a potential permit market. As stated above, the purpose of the analysis was to place the problem in context, provide some alternative strategies and, especially, to indicate the requirement for further research and data gathering before selecting a CO_2 emission policy.

The conclusions and recommendations both from the theory and case studies of permit trading and for the CO_2 case study are outlined in detail in Chapter 5.

Footnotes

[1]Environment Canada, *National Inventory of Sources and Emissions of CO_2, 1987* (Ottawa, Ontario: Environment Canada, June 1989).

[2]International Energy Agency, *Policy Measures and Their Impact on CO_2 Emissions and Accumulations* (Paris, France: International Energy Agency, December 7, 1989).

[3]Ibid.

[4]Canada, Ministry of Environment, *A Framework for Discussion on the Environment. The Green Plan* (Ottawa, Ontario: Minister of Supply and Services, 1990).

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[12]Ibid., p. 63.

[13]Environment Canada, *National Inventory*, 1989.

[14]Canadian Industry Program for Energy Conservation, *1988 Report*, 1988, p. 15.

[15]Environment Canada, *National Inventory*, 1989.

[16]Ibid.

[17]Ian Burn, *Energy-Related Carbon Dioxide Emissions in Alberta 1988-2005* (Edmonton, Alberta: Alberta Department of Energy, May 1990).

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[19]E.J. Wiggins, and W.J. Yurko, *The Greenhouse Effect and the Alberta Fossil Fuels Industry: A Discussion Paper* (Edmonton, Alberta: Alberta Oil Sands and Research Authority, July 31, 1989).

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[22]K. Morgan MacRae, *Critical Issues in Electric Power Planning in the 1990s*, CERI Study No. 33, Vol. 1 (Calgary, Alberta: Canadian Energy Research Institute, November 1989), p. 252.

[23]Ibid., p. 251.

[24]Ibid.

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[26]Dane B. MacCarthy, "Demand Management in Canada," in *Canadian Energy Research Institute Conference on Electric Power Planning in the 1990s* Held in Montreal, Quebec, June 3-5, 1990 (Calgary, Alberta: Canadian Energy Research Institute, 1990), p. 7.

[27]Canadian Industry Program for Energy Conservation, *1988 Report* (Ottawa, Ontario: Energy, Mines and Resources Canada, September 1989).

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

This study has dealt with both theoretical and practical aspects of permit trading as a background for analysing the feasibility of a CO_2 permit system in Canada. Accordingly, the conclusions are divided into two sections, dealing with the conditions for permit trading and the CO_2 case study respectively.

5.1 Conclusions from the Theory of Permit Trading

The theory of environmental economics promotes permit trading as a cost-effective way to control emissions. The least-cost solution rests on a number of theoretical assumptions that may or may not be fulfilled in practice. **The most important theoretical conditions for a successful permit trading market are: a sufficiently large and homogeneous number of sources to provide a competitive market without the possibility for market manipulative behaviour; a certain degree of variation in the costs of compliance between sources to provide benefits from permit trading; and the more unrealistic assumptions of perfect monitoring, enforceability and fluidity of capital to ensure policy effectiveness and full transferability of emission permits.**

Comparing a tax policy to emission trading, it was seen that for a quantity target, permit policy has the advantage of fixing the quantities of emissions without uncertainty, and of accommodating economic growth and inflation without erosion of the environmental standard. A tax policy, however, can be more easily applied to all sectors of the economy, while a permit system is only suitable for the larger, market-related processes. Furthermore, although fewer adjustments may be needed in a permit system and changing a tax rate is politically unpopular, it may prove difficult to make changes to a permit system once implemented.

Finally, the method of permit allocation constitutes an issue of wealth transfer, making it a politically sensitive

problem. To minimize the transfer payments generated by the initial allocation method, an auctioning system can be instituted, including a revenue refund if government revenue neutrality is desired.

The examination of the practical permit trading experience reconfirms the theoretical conditions of competitiveness, cost variation and transferability as a prerequisite to the establishment of a successful market. In addition, the issue of uncertainty with respect to property rights and the consequences this may have on the inter-temporal allocation of permits represents a problem in the practical application of permit trading.

Regulatory mechanisms which inhibit transferability and thereby restrain permit trading are essentially put in place to deal with the monitoring and enforcement problems that arise in practical applications. **The necessity to monitor sources, both to establish emissions equivalence of trades and to ensure compliance, can in effect jeopardize the cost-effectiveness and low information and administration requirements, which are the main theoretical benefits of permit trading.**

5.2 Conclusions for CO_2 Permit Trading in Canada

A CO_2 permit market in Canada should encompass large industrial sources and the electricity generation sector. Depending on how low the cut-off level for sources that require permits is set, the industrial sector would cover at least 20 percent of total national CO_2 emissions, and probably be comprised of approximately 200 firms. If power generation sources were included, it would bring the coverage of emission sources to approximately 40 percent. The possibility of including vehicle fleets from the transportation sector should also be investigated. In addition, continued research may open the possibility for a future expansion of the program to include other greenhouse gases such as methane and nitrous oxide, to allow for credits from reforestation or creation of other carbon sinks, and to allow for international permit trades.

It is particularly important that both the electric generation sector and the industrial end-users of energy are included in the same permit system. To the extent that industries pursue non-utility generation options, the changes in emissions profiles will be reflected in permit demand and price. Likewise, with an industrial electrification trend placing electric utilities under supply pressure, a permit

system will allow utilities to increase their product price to include the increasing price of permits for higher emissions. This ensures that deteriorating standards from shifting emissions between a regulated and an unregulated sector will not become a problem.

The final conclusion following from the discussion of source characteristics is the importance of including emissions from both self-produced and purchased fuels. For the most energy intensive industries, self-produced fuels represent a large and growing share of total fuel consumption. To exclude these would create a serious loop-hole in the emission policy.

A policy should also be open to innovative ways to reduce or capture CO_2. For example, if a company is involved in extensive reforestation or creates a carbon pond to reduce net emissions, the program should take this into account. It must be emphasized again that much more research is required to generate reliable and comprehensive information on the carbon cycle. Allowing for the possibility of creating credits for carbon sinks would be a way to actively encourage such research efforts, and to ensure that these options are pursued if they represent the most economically attractive means of reducing net emissions.

Since most CO_2 emissions arise from combustion of fossil fuels, energy efficiency improvements are the main vehicle for emissions reductions. Although significant improvements have been made, there is still an untapped potential for energy conservation within the energy-intensive Canadian industries. In addition to further research to uncover and exploit these emission reduction options, more research is required to improve technologies for CO_2 stripping and to ensure safe and permanent disposal.

The most serious challenges for a CO_2 permit policy will be to design an adequate method of initial allocation and to ensure compliance with the regulations. The method of initial distribution will represent a prescription for wealth transfer, unless an auction system is used. The administrative burden of an auction-refund system should be weighed against the equity issues of various free distribution formulae.

The problem of enforcement will exist for any emission policy. Efficient enforcement requires, above all, adequate monitoring and reporting routines. In addition, the penalty for noncompliance must be large enough to deter emitters from ignoring the regulations.

The problem of monitoring emissions by source remains. To evaluate monitoring options, it is necessary to undertake extensive analysis of the characteristics of CO_2 sources to determine levels of current emissions as well as the potential for emission variations due to changing operating conditions. The policy must also be designed to ensure that emitters have an incentive to facilitate easy and accurate monitoring of emissions. In addition to the source monitoring problems, a permit trading policy is faced with the very significant problem of verifying the equivalence of traded emissions.

Finally, a permit policy should, from the outset, specify the duration of permits to establish confidence in the property rights associated with emission trades. Failure to do this will create uncertainty and can seriously affect the incentive to trade. The expiration date must be set in accordance with a timetable for policy review and target revisions, but could be staggered to allow for a smoother transition. The lifetime of permits should reflect a compromise between the administrative burden and economic impact of re-issuing permits, and the desirability of revising and adjusting emission targets.

5.3 Recommendations for Further Work

Some general conclusions with respect to further analysis and data collection follow from the case study. First, it is clear that permit trading can only constitute one of several policy initiatives to reduce greenhouse emissions.

- **A permit trading policy can only be a partial answer to the problem, since it cannot address all the sources of CO_2 emissions. Complementary policies must be pursued for the residential, commercial, transportation and small industrial sectors, keeping the total emission target in perspective.**

Secondly, there is currently little understanding of the economic costs and transfer payments that a permit system would entail.

- **The economic impact of a potential permit trading system must be extensively analysed prior to implementation. The equity issues in the system for initial distribution of permits are of particular importance in this respect.**

Much more work is required to gain a complete and detailed inventory of CO_2 sources. This is necessary both to delineate a potential CO_2 permit market and to further analyse monitoring and enforcement strategies.

- **If industrial sources wish the government to pursue the option of permit trading, they need to demonstrate the feasibility of this policy. This involves creating a source inventory and demonstrating their willingness and ability to monitor emission sources and comply with such a policy.**

To accomplish these tasks will require a cooperative, consultative process between citizens, industries and governments. If the goal of freezing and eventually reducing CO_2 emissions is to be met, it is in everyone's interest to minimize the economic costs involved. The feasibility of a permit trading policy must be subjected to further, extensive analysis. Any policy must be carefully designed to avoid a large administrative burden and unintended wealth transfers, and to ensure compliance. Considering the potential economic dislocation from any CO_2 policy, the promise of a least-cost solution, which is the basis of a permit system, is worthy of further examination.

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